1963

Individual Differences in Thought Processes

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INDIVIDUAL DIFFERENCES IN THOUGHT PROCESSES

by

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A Dissertation Submitted to the Faculty of the Graduate
School of Loyola University in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Philosophy

September
1963

VITA

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In September 1958 she was admitted in the Graduate School of Loyola University in the Department of Education. She received the Degree of Master of Education in June 1960. Since that time she was employed as Research Assistent in the Loyola Psychometric Laboratory, and more recently as Research Associate.

ACKNOWLEDGEMENT

This research was conducted under the guidance of Dr. Horacio J. A. Rimoldi, Director of the Loyola Psychometric Laboratory, to whom the author wishes to express her gratitude for his advice in planning the research and his assistence during the completion of the study.

The author wishes to express her gratitude also to Mrs. Mary Jo. Lutzow and Mrs. Catherine Sheehan who made the presentation of this research possible.

This study was supported by the Cooperative Research Program of the Office of Education, U. S. Department of Health, Education and Welfare. Principal Investigator, H. J. A. Rimoldi, M.D., Ph.D.

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CHAPTER I

INTRODUCTION

Most of the studies to appraise individual differences using mental tests have been concerned with the development of group norms. Conclusions about an individual were attempted by reference to these norms or other statistics which by definition are based on averages for the group. The analysis of test results often pivots on the properties of responses to items that are classified as correct or incorrect.

In several studies (Rimoldi, Devane, 1961; Rimoldi, Meyer, Meyer, Fogliatto, 1962; Rimoldi, Haley, Fogliatto, 1962; Fogliatto, 1962; Rimoldi, Fogliatto, Haley, Reyes, Erdmann, Zacharias, 1962) it was found: 1) that the process employed in solving a problem cannot be characterized only by the final answer, 2) that by using group norms we may be unnecessarily eliminating important individual differences. These studies presented ways of preparing problems to appraise thinking ability.

In a recently published study (Rimoldi, Haley, Fogliatto, Erdmann, 1963) it was reported that it is important for the experimenter to be able to control the schemata of the problems as well as their content (see procedure). This made possible the development of new ways of scoring these problems. Being able to control the schemata and the content, it is possible to score individuals in relation to these. A comparison, then, can be made between the performance of an individual score in terms of schemata and content as well as in terms of the norms established by the group. This has been one of the problems investigated in this dissertation.

In previous research (Rimoldi, Devane, 1961; Rimoldi, Fogliatto, Haley, Reyes, Erdmann, Zacharias, 1962) it was found that training in problem solving improves the thinking process. In solving the problems, experimental subjects used fewer questions than the controls. More agreement was observed among the experimental subjects than among the control subjects as to the questions selected in order to solve the problems. The second problem undertaken in this research has been an investigation of the differences in the problem solving process between each experimental subject and the corresponding control subject who were matched according to specific criteria before the experiment.

In the study "Training in Problem Solving" (Rimoldi, Fogliatto, Haley, Reyes, Erdmann, Zacharias, 1962) it was reported: 1) that college students as a group select fewer questions in order to solve a problem than the high school students, 2)that the college group improves more under training than the high school group. A third problem investigated in this research was the importance of the educational level as a factor in problem solving performance.

Summarizing, the three main purposes of this research are: 1) To evaluate group performance versus performance norms based on the properties of the problem as well as the interaction of schemata and content. 2) To study individual performance by comparing the process of subjects with training to subjects without training individually matched before the experiment. 3) To investigate the effect that a particular educational level has on the performance of these problems.

CHAPTER II

REVIEW OF RELATED RESEARCH

A. Early studies in the field.

Waters (1928) studies the effect of the instruction upon ideational learning. The problem consisted in discovering the principle by which the subject could always draw the last bead. Six different types of tuition (instruction) were employed: a)The error method, b) The demonstration method, c) The attention method and three instruction methods that were explanation of the principle involved varying from simple to general. The problems to be investigated were: 1) The influence of various modes of tuition on the rate of learning. 2) The dependence of the efficiency of any method of tuition upon the time at which it was given and, 3) The influence of such tuition on the ability of the subject to solve a similar problem when no tuition was given and the subject worked on his own initiative.

The results showed: 1) The demonstration method is detrimental in both cases, in learning and in the solution of the second problem. 2) The error method exerts no appreciable effect. 3) The attention method is beneficial. 4) A short, concrete, easily remarked statement of the principle involved is more efficacious than a longer, more general or abstract one, both in learning the first problem and in mastery of a second.

Ruger (1926) using analytical and synthetical as well as bidimensional and tridimensional mechanical puzzles analized dynamical rather than structural human methods of meeting novel situations and of reducing their control to acts of skill. The results show that even in the cases when the main purpose was not to gain a new form of motor control but rather that of "learning by understanding", there are differences in human methods of learning. He observed that in almost every case the subjects were acting randomly, at least in part, and that many times the random behavior lead to the solution. In some cases, the subject had a very definite plan but "no cases were found in which a really novel puzzle was seen through at once". He studied also the plateaux or periods of little improvement. He found plateaux of long duration when the subject was changing methods of attacking the problem, and plateaux which were uniform and of short duration when the subject used a single method.

Doyle (1933) studied quantitative and qualitative different groups of subjects under four problem situations of varied complexity in order to discover similarity or differentiation between human inductive discovery and trial and error process in learning. The subjects were presented with a 4-key multiple choice key board. In problem situation A, the task of the subject was to discover the 2-key combination that will ring the bell. This was complicated by introducing time. The bell rung 4 seconds after the completion of the 2-key combination. In problem situation B, the subjects were instructed in order to promote a "scientific attitude and method". In problem situation C, the element of time was eliminated; and in problem situation D, time was again introduced but only 1-key board was involved in the solution of the problem.

The results show that after the first problem the subject was able to discover the principle involved, and the learning curve shows a "sharp drop" after the completion of the first problem. Qualitative protocols of the subjects, especially in "problem situation A" show a clear distinction between the process of "inductive discovery in problem situation", and the process of trial and error in learning.

Aveling (1912) set up an experiment in order to discover the "phenomenological character of consciousness" of the "universal" and the "individual"........"man, all man, this man". He presented the subjects with conditions similar to those of every day life. The experiment consisted of two parts: In the first part, he used ten nonsense words of two syllables each and ten sets of pictures with five pictures in each set. Each word was associated with a picture and presented to the subject. The subject had to repeat the word aloud while fixing his attention on both the picture and the word. For the second part of the experiment, he used the same nonsense words that the subject had learned, and presented them in an incomplete sentence. The subject completed the sentences by adding an adjective or a predicate.

He concluded that the nonsense words "acquire a general meaning gradually by a process of association with the object devoted to them". During this period a "concept is abstracted from objects and associated with the words". There is in the learning period a moment where the image is not necessary in order to have a thought, but the concept is always necessary. The universal does not need an image. We can think of man or of all men without images; but the individual needs a sensorial content or image.

In these earlier studies the thought process was considered differently than it is today and differently than what has been done in the present study.

B. Definition and classification of Problem Solving.

Since the contribution of Wertheimer (1945) a number of studies have been published in this area.

Wertheimer considers the distinction between productive and reproductive thinking as most important when viewing work of an academic nature. In a problem situation there is a goal, obstacles to reaching the goal, and no clear perception of the means of obtaining it.Wertheimer presented his problems to children and adults. In most cases "thinking" did not occur at all. Some of his subjects engaged in what Wertheimer called reproductive thinking. They offered answers which were simply the reproduction of past experience. Productive thinking on the other hand, according to Wertheimer, involves the kind of mental struggle which we find is not typical of the purely reproductive process. Seeing the problem in a new way involved what may be called recentering, reorganizing, or restructuring. What emerges is a new product, not a reproduction of past learning. It has often been pointed out that teachers have more interest in the outcome of thinking than in the process of thinking, and most educational work actually has as its aim the following of the thought process of the teacher or the writer of the text book. The emphasis is chiefly on reproductive thinking, rather than on productive or creative thinking. Wertheimer's contribution is the first study of the thought process that develops its conclusions from concrete examples. His approach differs from the present study. He presents a qualitative evaluation of the thought process. The present study is an attempt to evaluate quantitatively individual differences in thought processes.

According to Duncan (1959) thinking is most frequently defined as the integration and organization of past experience, while problem solving is defined as the discovery of correct response. Problem solving is considered to be fairly high on the discovery dimension, and this will be the distinction of problem solving from conditioning and rote learning, which are presumed to involve relatively little response discovery.

Underwood (1952) presents three methods for determing the amount of overlap between conditioning and thinking.

Bloom and Broder (1950) describe the difficulties of attempting to discover the nature of mental processes through retrospection, introspection, or the construction of test situations in which each of a variety of methods of attack would be reflected by a different solution. They classified the students as successful or unsuccessful according to their aptitude scores and marks on comprehensive examinations. The students were asked to think aloud while they were solving the problems. In collecting data, notes were taken as completely as possible on everything that the subject said or did. The successful problem solver showed greater ability to understand the nature of the problem and to attack it in its own terms. The unsuccessful problem solvers showed lack of comprehension of direction and often presented solution of a problem other than the one that was expected. "The nonsuccessful problem solvers started the problem with no apparent plan for solution. They jumped from one part of the problem to another, giving insufficient consideration to any one part to enable them to find a point of departure. They were easily sidetracked by external considerations, and their thoughts would go off on a tangent, coming back to the problem only with considerable difficulty."

Bruner, Goodnow, and Austin (1956) described classes of equivalence categories. "Functional categories" include at least those problem solving tasks where the subjects must categorize an object as fitting a certain function. They also suggest that defining attributes are sometimes combined to create either new or empty categories, and that those types of combination often occur in problem solving. They attempt to relate two major areas of thinking research, i.e., problem solving and concept formation.

Tate, Stanier and Harootunian (1959) classified students as good and poor problem solvers using as criteria their performance in a battery of tests, one of which was the "Thought Problems", a test that was especially prepared for that study. They concluded that the "good problem solvers are significantly better than the poor in nearly all tests where quality of response, accuracy, or judgment is required; and that, without exception, the more complex the task or the more restricted the requirements, the greater their superiority."

In the present study no attempt has been made to categorize the problem solvers. The Thought Problems have been used here for matching purposes. Individual differences has been evaluated using a different approach.

C. Training in problem solving.

A considerable number of studies have discussed ways of training people in problem solving tasks. Adams (1954) has found that a group of subjects trained on repeated presentations of the same problem were more efficient in solving new problems of the same class than a group trained on a number of different problems. Harlow (1949) held that training on a number of different problems will develop new ideas in the way of how problems should be attacked. This means that such a training will help the subject in the new situation.

Schroder and Rotter (1952) used a card sorting task with four groups of subjects and they altered the training in "the expectancy of change" given from group to group. According to the authors it is the training in "expectancy of change" which is required, and no training in a single solution that will solve the problem in the present situation.

Duncker (1945) conducted a study with educated adults. They were presented with arithmetic and geometric problems. In solving the problems the subjects had to analyze what was given and what was required. The process of solving a problem consisted in the generation and testing of hypotheses. Past experience plays an important role in the solving of new problems. The inability to use an object for a strange purpose in a given situation may be due to the previous use made of that object. Previous experience can have a negative effect when new problem situations are faced. Birch and Rabinowitz (1951) have also showed this effect and Adamson (1952) repeated three of Duncker's experiments with the same results.

Parnes and Meadow (1960) compared experimental subjects with control subjects matched for vocabulary ability on six creative ability tests. They reported differences statistically significant. The increase of productivity in the creative thinking process produced by the creative problem-solving course persisted for a period of at least eight months after the completion of the course.

Sommer (1960) reported a study with two groups of subjects. The experimental group received, before the experiment, correct solutions to problems involving the same principle as those in the experimental situation. The results showed: 1) wide differences between the two groups on the process leading to the solution; 2) once the solution to a problem has been experienced, it exerts a profound influence on the approach to similar problems; and 3) the use of a learned principle becomes more difficult if the problem is presented in a confusing manner. Blumenfeld (1956) reported two studies using geometrical theorems in which he changed the orientation and the figure. Buswell (1956) attempted to define common patterns in the solution of problems. The subjects were asked to discover a rule for arriving at the solution of an addition problem without the use of simple addition. The subjects found the problem very difficult and the results indicated more diversity than similarity in the problem solving approach. When the effect of training was tested in similar problems, about half of the subjects showed transfer.

In a study with high school students Rimoldi and Devane (1961) found that the experimental subjects - the group of subjects who went through a training period in problem solving - had a greater gain in mathematics grades than the control subjects.

A recent publication by Rimoldi, Fogliatto, Haley, Reyes, Erdmann, and Zacharias (1962) reported a research conducted with high school and college students. The design of the experiment permitted the testing of the influence that training in one type of problems would have on another type of problems. Transfer of training was found. It was also found that the subjects with training in problem solving use fewer questions and show more agreement among themselves as to which questions they should ask in order to solve the problem than the control subjects. Similar results were also found when the trained subjects were introduced to new problems.

The experiments described in the previous paragraphs have dealt with the effect of prior experience. It has been demonstrated that training in a particular type of problems leads to maximum efficiency as long as the problem requires a similar solution. When different kinds of problems have to be faced, a wider training with emphasis on the need for change seems to be advisable. In the present research the effect of training has been studied at the individual level both in problems that require a similar solution and in completely different problems.

D. Presentation of the problems.

A number of studies have been reported in which the same problem has been presented under different modes or appearances. Many problems have been presented in either symbolic or concrete form with various degrees in between. Several studies have found no effect of varying concreteness on the problem. Saugstad (1957) in a repetition of Maier's experiment found that the miniature scale model did not call more attention to ceiling than the real presentation of the two pendulum problems. The same was reported by Lorge, Tuckman, Aikman, Spiegel, and Moss (1955a, 1955b) when they used the mined road problem at seven levels of reality (verbal, photographic, miniature scale model or real presentation, or various amounts of manipulation of the scale and real versions).

On the other hand contrary results have been reported. Cobb and Brenneise (1952) reported that "anchor real and extension solution of the two-string problem" decreased as concreteness decreases over four steps. Gibb (1956) tested children in subtraction problems with three degrees of concreteness. He found significant differences and no interaction. Rimoldi, Fogliatto, Reyes, Haley, Erdmann, Zacharias (1962) have reported a significant interaction (schemata-content) using problems with three different schemata and four contents for each one of them. In the present project, problems with three degrees of complexity and four degrees of concreteness has been studied.

E. The importance of age in problem solving.

Several studies have reported that age is an important variable in most types of problem solving. Sate (1953) working with children and adults had found that the former were more affected by the amount of training than by the difficulty level of the problems, while the reverse was true for adults. Hunter (1957) reported that 16 year olds did better than 11 year olds on his syllogistic-like problems. Moraes (1954) found different patterns of thinking among school children of different ages on arithmetic reasoning problems. Rimoldi, Fogliatto, Haley, Reyes, Erdmann, Zacharias (1962) found that college freshman use fewer questions in order to solve a problem than do high school freshman. It was also found that the college students as a group improve more under training than high school students. In the present study the importance of educational level has been investigated using high school freshman and college freshman as subjects.

Rimoldi, Meyer, Meyer, Fogliatto (1962) report a research with graduate students (from 23 to 40 years old) in which the description and analysis of the sequential organization of complex process was studied (i.e., problem solving) and also how these change from early life to old age. New research, not yet reported, has made use of information theory in which a series of problems have been administered to subjects of varied age level (from 11 to 80 years old). Tentative results indicate that uncertainty in problem solving decreases with chronological age to the young adult level and then gradually increases.

F. Methodology.

Johnson (1955) discussed three techniques for the analysis of individual differences in thought processes. 1) comparison of groups (in respect to age, sex, education, or ways of attacking the problem). 2) correlational analysis (the time of solution, number of responses, number of right answers). 3) factor analysis.

Vinacke (1952) distinguished three stages of behavior during problem solving situations: a) confrontation of the problem, b) working toward the solution, and c) solution, or failure to solve the problem. Once the individual knows that there is a problem to be solved, he attacked it. The three principal modes of attacking a problem are: a) trial and error, b) insight and c) gradual analysis. A mode of attack will lead the subject to one of the four kinds of solution: a)immediate, b) gradual, c) steady, or d) sudden.

A technique similar to the one to be used in this study was devised by Bryan (1954) for evaluating electronic trouble shooting. Glaser, Damrin, and Gardner, (1954) presented a similar technique, the Tab Item Technique, which was also used in electronic trouble shooting. John and Rimoldi (1955) and John (1957) studied the sequential properties of complex reasoning by means of the Problem Solving and Information Apparatus. This apparatus may be useful in studying certain phases of abstract reasoning, but cannot be used in a variety of situations where less abstract problems are examined.

The technique used in this study was devised by Rimoldi (1955). The technique was first applied to study mental processes in medical students. A series of studies related to this approach have been published by the Loyola Psychometric Laboratory over a period of several years (Rimoldi, 1960, Rimoldi, 1961, Rimoldi, Devane, and Haley, 1961).

A final report by Rimoldi, Haley, Fogliatto (1962) summarized the whole work. This approach has been applied to other areas than medicine (Tabor, 1959, Mohrbacher, 1960, Gunn, 1961, Rimoldi, Meyer, Meyer, Fogliatto, 1962, Fogliatto, 1962). The same technique has been used to evaluate the effect of training in high school students (Rimoldi and Devane, 1961) and in high school and college students (Rimoldi, Fogliatto, Haley, Reyes, Erdmann, and Zacharias, 1962).

The studies described in the previous paragraphs deal with evaluation of the subjects' performances using group norms. In the present research the performance of the subjects in problem solving has also been studied using schemata norms as described by Rimoldi, Haley, Fogliatto, and Erdmann (1963).

CHAPTER III

PROCEDURE

A. Design of the experiment:

1. Pre-testing sessions: every subject whether control or experimental received at the beginning of the experiment 3 problems of type c. (see problems).

2. Training sessions: the experimental subjects (high school and college) completed at least 24 problems - 12 of type a and 12 of type b. (see problems).

3. Post-testing sessions: every subject whether control or experimental received at the end of the experiment:

a) the same 3 problems of type c that were administered at the beginning.

b) 2 problems of type a similar to the ones used in training sessions.

c) 2 problems of type b similar to the ones used in the training sessions.

d) 2 new problems completely different from the ones used in the training sessions (1 of type a and 1 of type c).

B. Subjects:

The subjects used in this study consist of a group of 38 experimental subjects (19 male high school and 19 male college freshman) and 38 control subjects (19 male high school and 19 male college freshman).

1. The high school subjects were selected among the freshmen of St. Ignatius High School, Chicago, Illinois, if they had an I.Q. of 118 or above on the Henmon-Nelson Test of Mental Abilities. On this basis seventy students were selected. The Raven's Progressive Matrices Tests and Thought Problems, Part 1, were administered to all of them. Nineteen experimental-control pairs were selected and each pair matched for I.Q., and for the score on the Raven Progressive Matrices Test. The subjects after being matched were randomly assigned to be a control or experimental subject.

2. For the college subjects, 50 were selected among the freshmen of Loyola University College of Arts and Sciences. The Raven Progressive Tests and Thought Problems, Part I, were administered to all of them. Using their scores on these two tests, 19 experimental-control pairs were selected. Each member of the pair was randomly assigned to be an experimental or control subject. For the college students, it was not possible to match them according to I.Q. because school records could not easily be compared.

The Mean, Standard Deviations and Number of Subjects for the I.Q.'s, the Raven's Progressive Matrices Tests, and the Thought Problems, Part I, are presented in Table 1.

Table 2 presents the correlation for the matched pairs.

TABLE I

MEAN, STANDARD DEVIATION AND NUMBER OF SUBJECTS FOR RAVEN, I.Q. AND THOUGHT PROBLEMS PART I FOR HIGH SCHOOL AND COLLEGE STUDENTS

Tests	High School Control			High School Experimental			College Control			College Experimental		
	M	σ	N	M	σ	N	M	σ	N	M	σ	N
Raven	49.74	4.26	19	48.84	4.25	19	51.84	5.01	19	52.53	4.49	19
I.Q.	125.21	7.30	19	125.68	7.38	19						
Thought Problems, Part I	11.29	3.39	19	11.91	3.99	19	13.24	3.56	19	13.67	3.40	19

TABLE II

MATCHED PAIR CORRELATIONS FOR HIGH SCHOOL AND COLLEGE STUDENTS

High School	Raven Test	.94
	Henmon-Nelson I.Q.	.98
College	Raven Test	.89
	Thought Problems, Part I	.82

C. Problems:

Three different types of problems are used in this research. Every problem was individually administered to the subjects in all the sessions. A sample of the problems are presented in the appendix.

1. Problems of type a.*

The subject is presented with a problem and a set of questions from which he may select as many questions as he wishes and in any order that he desires. Each question is presented on a separate card. The answers are presented on the reverse side of the cards. When the subject thinks he has enough information, he stops selecting questions and gives his answer. He records the questions that he has asked in the corresponding order as well as the answer.

Problems of type a are problems 31, 33, and 35. The numbers refer to degrees of complexity in the schemata.

For problems 31 the schemata can be represented as a tree

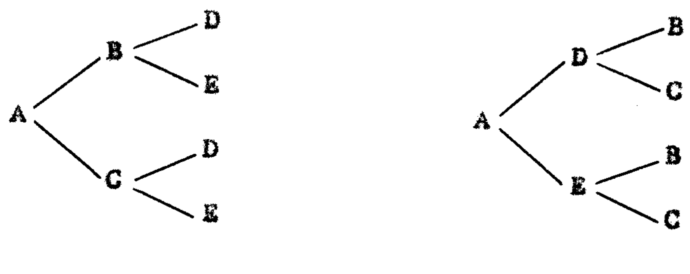

FIGURE I

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*These problems have been developed by the experimenter in collaboration with the Director and other members of the Loyola Psychometric Laboratory.

or a fourfold table with degrees of freedom

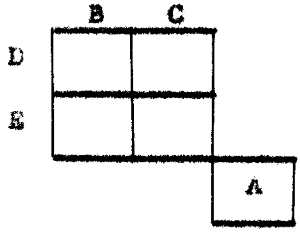

FIGURE 2

For problem 33 as

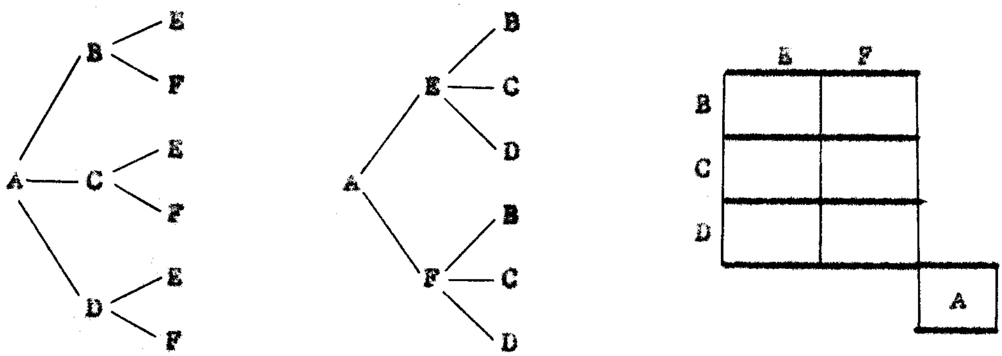

FIGURE 3

For problems 35 as

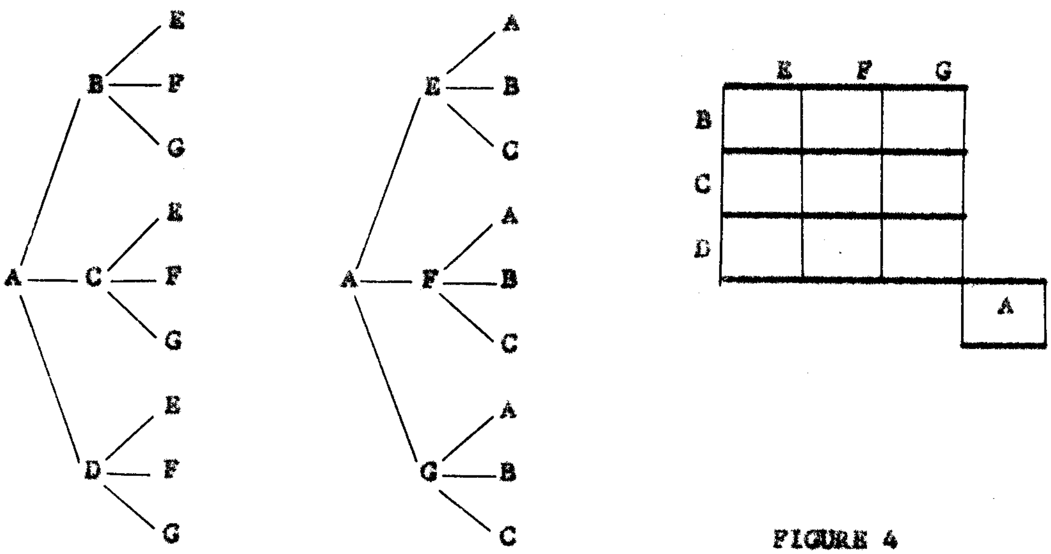

FIGURE 4

Each of these problems has four forms. In form A the problem is presented in a concrete way. Form B is an abstract presentation of the problem. Form C is a negative presentation of the problem. In form D the answers are given in letters instead of using numbers as in forms A, B, and C.

At least 12 problems of type <u>a</u> were completed by the experimental subjects during the training sessions. In the post-testing sessions the 2 problems of type <u>a</u> were: 31D' and 35B'. They have the same schemata as 31 and 35 and the content of form D and B respectively.

A new problem of type <u>a</u> was also used in the post-testing sessions; this is problem 41A. The schemata can be represented as a matrix.

Receive

		N			S					
		A	B	C	D	E	F	G	H	
N	A							0		0
	B	+		+				0		2
	C				+	+		0		2
Initiate	D							0	+	1
	E	+	+	+	+		+	0		5
S	F							0		0
	G	0	0	0	0	0	0		0	0
	H							0		0
		2	1	2	2	1	1	0	1	10

FIGURE 5

2. Problems of type b *

In problems of type b the subject is presented with a drawing; he has to identify an area pre-selected by the experimenter. In this type of problem, the subject generates his own questions. After asking several questions, the subject will understand the principle involved in the problem, then he will indicate his solution for the preselected area. As in the case of problems of type a, he will record the questions he has asked in the order that he has asked them and record the answer upon which he has decided.

Problems of type b are problems 32, 34, and 36. Each one of these problems has a different figure. For every figure four different forms (A,B,C, and D) were developed. Form A is the most simple and form D the most complex with two degrees of complexity in between (B and C). Every subject in the experimental group completed at least 12 problems of type B. In the post-testing sessions, 2 problems of type b were administered (32F and 36F). They have the same figure as problems 32 and 36 respectively. Nevertheless, for problem 32F the principle involved was varied. When problem 32 was used in the training sessions, the underlying rationale was a series of letters or numbers or combinations of both following a horizontal pattern. In problem 32F a series of numbers was used but followed a vertical pattern. For problem 36F the same figure and content as the one used in the training sessions was kept.

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* These problems have been developed by the experimenter.

3. Problems of type _c_*.

In problems of type _c_ the subject is presented with a problem and a set of questions, or a figure and a set of questions. The subject proceeds in the same way as in problem of type _a_. Problems of type _c_ are problems 1, 19, and 25 which were used in the pre and post-testing sessions and problem 26 which was used only in the post-testing sessions. Problems 1 and 25 are figure problems and problems 19 and 26 are word problems.

D. Methodology.

1. Scoring methods:

a) Group Norms:

The subjects were scored in terms of group norms using a technique devised by Rimoldi (1960). This technique utilizes the frequency of selection of a specific question in a particular order. These frequencies are converted to proportions to indicate the percentage of the total group that respond using a specific question in that order. In order to score a subject the proportion corresponding to every question asked is accumulated in the corresponding order. This gives the observed score (0).

Proportions for every card in every possible order are also computed on the basis of randomness. By subtracting these proportions (E) based on randomness from the observed (0) proportions a table of (0-E) is computed. Using these proportions, it is possible to obtain a (0-E) score for every subject by accumulating the (0-E) proportions corresponding to any questions he asked in the corresponding order.

* These problems were available at the Loyola Psychometric Laboratory from previous research (Cooperative Research Project No. 1015)

With these norms every experimental subject was scored in all the problems of the training sessions.

b) Schemata Norms:

Problems of type a:

A scoring method described by Rimoldi, Haley, Fogliatto and Erdmann (1963) was used for problems of type a in order to score the subjects in terms of schemata norms. This technique is based on the properties of the problems. This means that the frequency of selection of each question in a particular order is established in terms of the sequence of logical relationships involved. As in the previous method these frequencies are converted to proportions to indicate the percentage of the total possible selections (as indicated by the schemata) for that specific question in that particular order.

This gives a table of observed proportions (O_s). A table (O_s-E) proportions is also computed. The procedure for scoring the subjects is similar to the one used with group norms.

The experimental subjects were scored using these norms on the 12 problems of the training sessions and on the 3 problems of the post-testing sessions. The control subjects were scored on the 3 problems of the post-testing sessions.

Problems of type b:

For this type of problem there is no pre-established sequence of questions to be asked in order to solve the problem. The subjects originate their own questions. They can start asking about the areas in any order they want or according to some possible sequence that they may discover by inspection of the figure. For example, some figures have lines of different colors or of different kinds (straight, curved, dotted,etc.) or a combination of both. This could suggest to the subject that there is some relationship between the color and kind of lines and the answer to the problem. Nevertheless, this does not always happen. Problem 32 (A,B,C,D) have different kinds of lines and the rationale involved has nothing to do with it. In problem 34 (A,B,C,D) different color and kind of lines were used and the answer depends only upon the color. Problem 36 (A,B,C,D) has the same figure with different colors and kinds of lines. In form A only the colors are important, for form B the answer depends only on the kinds of lines and in forms C and D the answers depend upon the colors and kinds of lines. This means that the subject should try different approaches before finding the solution. It is not possible to say that one approach is better than the others. But, it is possible to limit the number of questions that are necessary in order to solve the problem. On this basis the so called "schemata norms" have been developed for every problem of type b. Using this approach the subjects will receive a score on each question asked until he completes the necessary number of questions needed to solve a problem. After that for every question he asks, he will receive a score of zero. This means that when the performance curves are plotted, the plateau will be always found at the end of the curve. Using a similar approach as on problems of type a (O_s) and (O_s-E) score is given to each subject.

The score obtained by accumulating the proportions for all the questions necessary in order to solve the problem (provided that the subject has asked at least the minimum number) is divided by the total number of questions asked. If the subject asks less than the required number of questions, he will receive a score for every question he has asked; but, in order to find his final score the cumulative sum of scores will be divided by the specified number of questions.

Using this approach every experimental subject has been scored on every one of the 12 problems used in the training sessions and on the 2 problems of the post-testing sessions. The control subjects have been scored on the 2 problems of the post-testing sessions.

Problems of type c:

The schemata norms for the problems of type c are based on the principle of the process of elimination. This means that the question that eliminates the largest number of areas (in the case of a figure) or possible answers (where it applies in the case of a word problem) should be asked first. The question eliminating the next largest number of areas or answers should be chosen second, and so on until the final solution is reached. After the sequence has been developed, it is processed the same as problems of type a.

Every subject whether control or experimental has been scored using these norms on the 3 problems of the pre-testing sessions and on the 4 problems of the post-testing sessions.

2. Performance curves:

The performance curves indicate the subject's approach to the problem. They are obtained by plotting the score of the subjects at each step. The way that a subject has attacked the problem can be compared with the tactic used by another subject. It is possible to compare the tactic of a control subject with the tactic used by his corresponding matched experimental subject. It is also possible to see the tactics that an experimental subject has followed throughout the tests in the training sessions.

Performance curves have been drawn for every control and experimental pair using schemata norms in the problems of the pre and post-testing sessions. (The performance curves of a control-experimental pair are presented in figures 26 to 33 inclusive).

For the experimental subjects performance curves have been drawn using both schemata and group norms for every problem of the training sessions.

Figures 14 to 25 present the performance curves for an experimental subject throughout all the problems of the training sessions in the order that he has received them.

When group norms are used for drawing the performance curves they will always show an increment on the curve because the scores are accumulated. Nevertheless, the degree of increment will depend on the group, that is, a question that has been selected by a larger number of subjects in the group will have a very high score and consequently the performance curve will show a large increment at that point. By the same token a card that has been selected by just one subject in the group will have a very small value even if the question is a very useful one.

When the performance curves are based on schemata norms, the curve will not always show an increment. There will be moments when the subject had selected a useless question and no increase will be shown on the curve. These plateaux can appear at any moment on the curve for problems of type a and c (see figures 26,28,29 and 33). For problems of type b, by the way that schemata norms have been defined, these plateaux will always appear at the end of the curve (See figures 31 and 32).

3. Convex sets:

The convex sets are obtained by plotting for every subject the (O_s) score on the abscissa and the (O_s-E) score on the ordinate (Rimoldi, Haley, 1962). Drawing successive lines from one extreme point to another, a poligonal convex set is defined in such a way that any corner of the poligonal convex set will represent a sequence followed by a subject; the other sequences or tactics will fall inside the convex set or on the boundaries. It is clear; that the convex set corresponding to the tactics followed by the experimental subjects will not necessarily coincide with the convex set, that emerge from the tactics followed by the control subjects.

Convex sets have been drawn for every problem of the pre and post-testing sessions using schemata norms. It is possible to compare the performance of the control and the experimental subjects, and also to compare the college with the high school students. The convex sets for the high school and college students are presented in figures 34 to 57 inclusive. The numbers correspond to a subject who represents a tactic. The tactic on the boundaries of the convex sets are given at the bottom of the figures. Notice that the same score can be obtained using different tactics. But, the reverse does not hold; a tactic will always have the same score regardless of the subject who worked the problems.

CHAPTER IV

ANALYSIS OF THE DATA AND FINDINGS

A. Training sessions

1. Experimental subjects

a) Group norms.

The problems used in the training sessions are 31A,B,C,D; 33A, B,C,D; 35A,B,C,D; 32A,B,C,D; 34A,B,C,D; and 36A,B,C,D.

After scoring every experimental subject on all these problems using group norms analyses of variances were performed separately for high school and college students as well as for problems of type a and problems of type b. Tables 3 and 4 present the results of the analyses of variances for the high school students in problems of type a and in problems of type b respectively. Similar analyses of variances were performed for the college students and the results are presented on tables 5 and 6.

Of great interest here is to test the effect that the complexity of the problem represented by the schemata and the effect the familiarity of the content have on the process of solving these problems. The interaction between schemata and content is also of interest.

The "F" ratio for the main effect schemata and for the interaction between schemata and content are significant at the .001 level in all cases. This means that the complexity of the schemata is a significant source of variation. The "F" ratio for the main effect content is significant at the .001 level for the college students in problems of type a and in problems of type _b_. For the high school students the "F" ratio is significant at the .01 level on problems of type _b_ and not significant on problems of type _a_.

Figures 6 and 7 present the mean of the accumulative score (group norms) for high school students on problems of type _a_ and on problems of type _b_. Similarly, figures 8 and 9 present the mean of the accumulative score for the college students. Inspection of all these figures show that the interaction between schemata and content is highly significant in every case.

TABLE III

ANALYSIS OF VARIANCE FOR PROBLEMS OF TYPE a (TRAINING SESSIONS) ON THE HIGH SCHOOL STUDENTS BASED ON GROUP NORMS

Source	Sum of Squares	df	Variance Estimate	F
Main Effects:				
Schemata	.023285	2	.011642	8.94xxx
Content	.003281	3	.001093	1.06
Subjects	.017033	18	.000946	
Interaction:				
Schemata X Content	.021671	6	.003611	4.24xxx
Schemata X Subjects	.046894	36	.001302	
Content X Subjects	.055450	54	.001026	
Interaction:				
Schemata X Content X Subjects	.092113	108	.000852	
Total	.259727	227		

xxx $p < .001$

TABLE IV

ANALYSIS OF VARIANCE FOR PROBLEMS OF TYPE b (TRAINING SESSIONS) ON THE HIGH SCHOOL STUDENTS BASED ON GROUP NORMS

Source	Sum of Squares	df	Variance Estimate	F
Main Effects:				
Schemata	.063380	2	.031690	23.81^{xxx}
Content	.008777	3	.002925	5.52^{xx}
Subjects	.151939	18	.008441	
Interaction:				
Schemata X Content	.050606	6	.008434	10.06^{xxx}
Schemata X Subjects	.047924	36	.001331	
Content X Subjects	.028644	54	.000530	
Interaction:				
Schemata X Content X Subjects	.090540	108	.000838	
Total	.441810	227		

xx $p < .01$

xxx $p < .001$

TABLE V

ANALYSIS OF VARIANCE FOR PROBLEMS OF TYPE a (TRAINING SESSIONS) ON THE COLLEGE STUDENTS BASED ON GROUP NORMS

Source	Sum of Squares	df	Variance Estimate	F
Main Effects:				
Schemata	.147868	2	.073934	48.74^{xxx}
Content	.064169	3	.021389	29.50^{xxx}
Subjects	.035722	18	.001984	
Interaction:				
Schemata X Content	.125846	6	.020974	23.18^{xxx}
Schemata X Subjects	.054636	36	.001517	
Content X Subjects	.039191	54	.000725	
Interaction:				
Schemata X Content X Subjects	.097786	108	.000905	
Total	.565218	227		

^{xxx} $p < .001$

TABLE VI

ANALYSIS OF VARIANCE FOR PROBLEMS OF TYPE b (TRAINING SESSIONS) ON THE COLLEGE STUDENTS BASED ON GROUP NORMS

Source	Sum of Squares	df	Variance Estimate	F
Main Effects:				
Schemata	.029046	2	.014523	24.29^{xxx}
Content	.021903	3	.007301	11.52^{xxx}
Subjects	.039128	18	.002173	
Interaction:				
Schemata X Content	.057309	6	.009551	22.63^{xxx}
Schemata X Subjects	.021568	36	.000599	
Content X Subjects	.034289	54	.000634	
Interaction:				
Schemata X Content X Subjects	.045614	108	.000422	
Total	.248857	227		

xxx $p < .001$

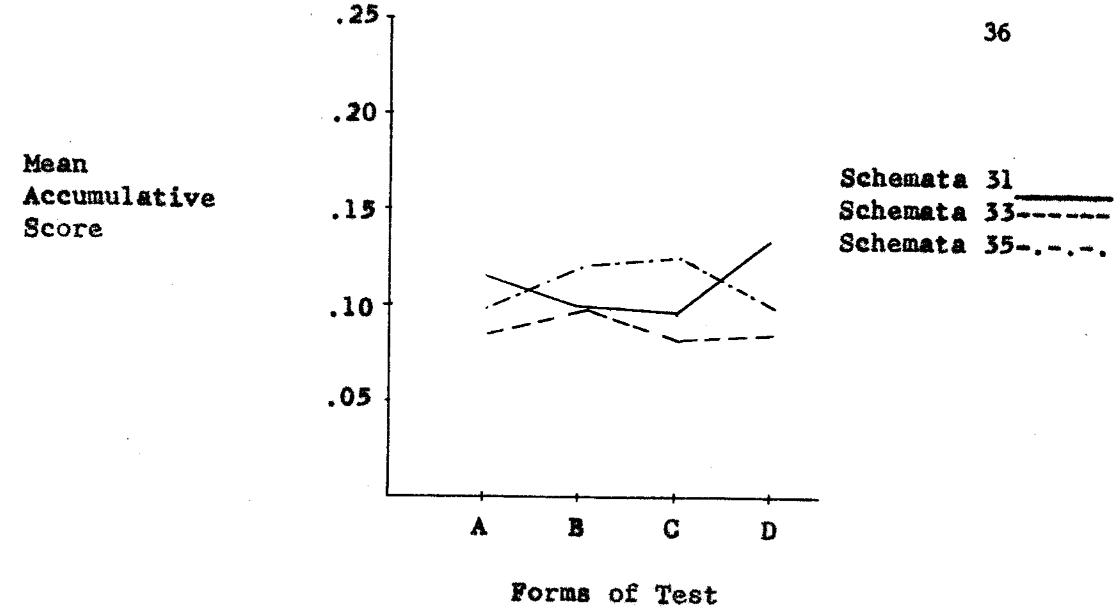

FIGURE 6

MEAN ACCUMULATIVE SCORE (GROUP NORMS) OF HIGH SCHOOL SUBJECTS ON PROBLEMS 31, 33, and 35 (TYPE a) FOR THE FOUR FORMS OF EACH PROBLEM

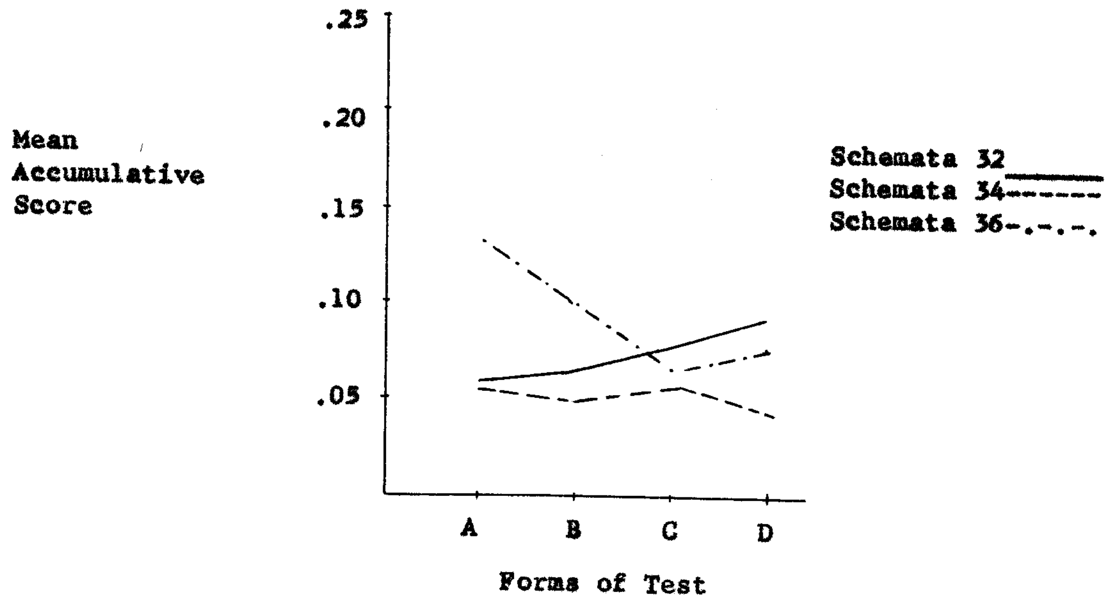

FIGURE 7

MEAN ACCUMULATIVE SCORE (GROUP NORMS) OF HIGH SCHOOL SUBJECTS ON PROBLEMS 32, 34, and 36 (TYPE b) FOR THE FOUR FORMS OF EACH PROBLEM

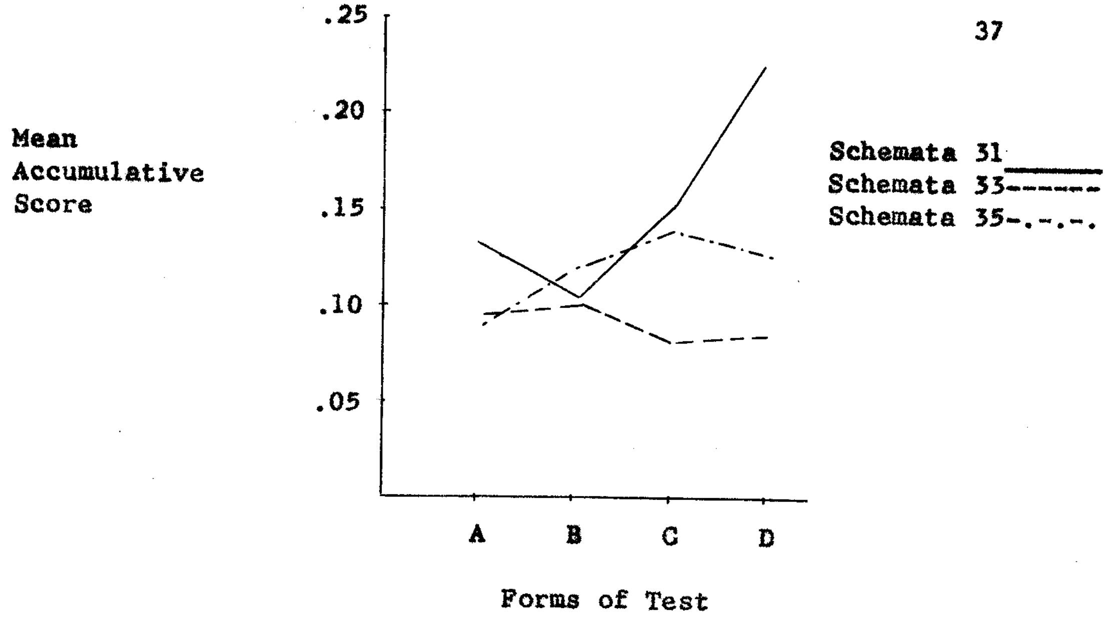

FIGURE 8

MEAN ACCUMULATIVE SCORE (GROUP NORMS) OF COLLEGE SUBJECTS ON PROBLEMS 31, 33, and 35 (TYPE a) FOR THE FOUR FORMS OF EACH PROBLEM

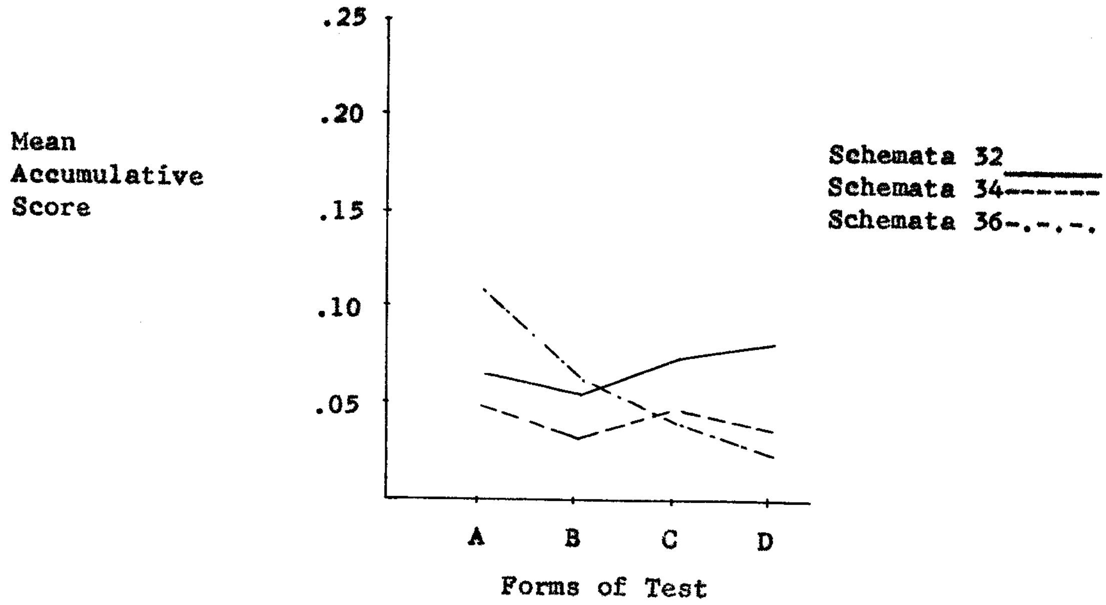

FIGURE 9

MEAN ACCUMULATIVE SCORE (GROUP NORMS) OF COLLEGE SUBJECTS ON PROBLEMS 32, 34, and 36 (TYPE b) FOR THE FOUR FORMS OF EACH PROBLEM

b) Length of plateaux.

Every experimental subject was also scored using schemata norms. After drawing the performance curves for every subject in every problem of the training sessions, the lengths of plateaux were calculated. Using the length of plateaux for every subject in every problem, analyses of variances were performed separately for high school students and for college students as well as for problems of type a and problems of type b. Tables 7 and 8 present the results of the analyses of variances for the high school students, tables 9 and 10 for the college students.

For the college students the "F" ratio for the main effect schemata, the main effect content, and the interaction between schemata and content are significant at .001 level for problems of type a and for problems of type b.

For the high school students the "F" ratio for the main effect schemata and the main effect content are significant at the .001 level for problems of type a. The "F" ratio for the interaction between schemata and content is not significant.

For problems of type b with the high school students, the "F" ratio for the interaction between schemata and content is significant at the .001 level. The "F" ratio for the main effect schemata is significant at the .05 level while the "F" ratio for the main effect content is not significant.

Figures 10 and 11 present the mean length of plateaux for high school students on problem of type a and b respectively. Looking at these figures it is possible to see that the interaction between schemata and content is highly significant for problems of type b, but not significant for problems of type a.

Figures 12 and 13 present the mean length of plateaux for the college students on problems of type a and b respectively. Inspection of these figures shows that the interaction between schemata and content is highly significant for problems of type a and for problems of type b.

In summary; the results of analyses of variance using group norms and the analyses of variance performed using length of plateaux shows that the schemata and content as well as the interaction between schemata and content are significant sources of variation. This is more significant for the college students.

TABLE VII

ANALYSIS OF VARIANCE FOR PROBLEMS OF TYPE a (TRAINING SESSIONS) ON THE HIGH SCHOOL STUDENTS BASED ON LENGTH OF PLATEAUX

Source	Sum of Squares	df	Variance Estimate	F
Main Effects:				
Schemata	295.061	2	147.500	12.13[xxx]
Content	112.574	3	37.525	8.71[xxx]
Subjects	750.333	18	41.685	
Interaction:				
Schemata X Content	50.413	6	8.402	1.75
Schemata X Subjects	437.772	36	12.160	
Content X Subjects	232.509	54	4.306	
Interaction:				
Schemata X Content X Subjects	440.755	108	4.811	
Total	2319.417	227		

[xxx] $p < .001$

TABLE VIII

ANALYSIS OF VARIANCE FOR PROBLEMS OF TYPE b (TRAINING SESSIONS) ON THE HIGH SCHOOL STUDENTS BASED ON LENGTH OF PLATEAUX

Source	Sum of Squares	df	Variance Estimate	F
Main Effects:				
Schemata	402.973	2	201.486	4.79[x]
Content	78.364	3	26.121	2.36
Subjects	1985.535	18	110.306	
Interaction:				
Schemata X Content	271.728	6	45.288	4.31[xxx]
Schemata X Subjects	1512.858	36	42.023	
Content X Subjects	597.552	54	11.065	
Interaction:				
Schemata X Content X Subjects	1135.108	108	10.510	
Total	5984.118	227		

[x] $p < .05$

[xxx] $p < .001$

TABLE IX

ANALYSIS OF VARIANCE FOR PROBLEMS OF TYPE *a* (TRAINING SESSIONS) ON THE COLLEGE STUDENTS BASED ON LENGTH OF PLATEAUX

Source	Sum of Squares	df	Variance Estimate	F
Main Effects:				
Schemata	188.008	2	94.004	30.73[xxx]
Content	141.561	3	47.187	19.87[xxx]
Subjects	271.868	18	15.103	
Interaction:				
Schemata X Content	60.334	6	10.139	4.97[xxx]
Schemata X Subjects	110.159	36	3.059	
Content X Subjects	128.272	54	2.375	
Interaction:				
Schemata X Content X Subjects	220.333	108	2.040	
Total	1121.035	227		

[xxx] $p < .001$

TABLE X

ANALYSIS OF VARIANCE FOR PROBLEMS OF TYPE b (TRAINING SESSIONS) ON THE COLLEGE STUDENTS BASED ON LENGTH OF PLATEAUX

Source	Sum of Squares	df	Variance Estimate	F
Main Effects:				
Schemata	186.061	2	93.030	9.47[xxx]
Content	261.000	3	87.000	6.67[xxx]
Subjects	715.710	18	39.761	
Interaction:				
Schemata X Content	630.079	6	105.013	17.53[xxx]
Schemata X Subjects	353.606	36	9.822	
Content X Subjects	704.500	54	13.046	
Interaction:				
Schemata X Content X Subjects	646.921	108	5.990	
Total	3497.877	227		

xxx $p < .001$

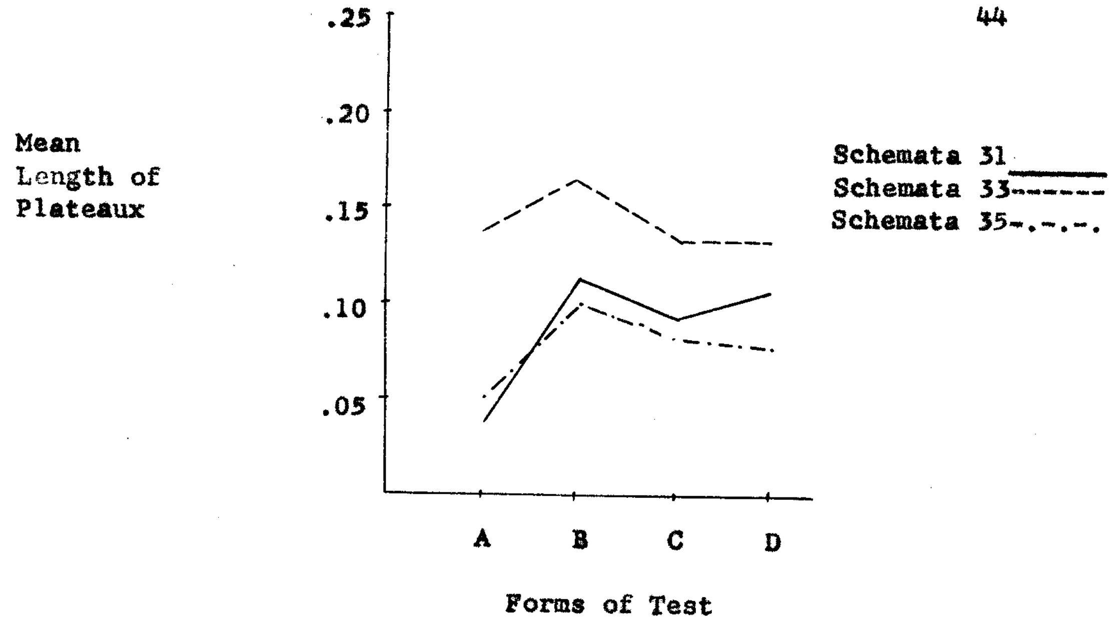

FIGURE 10

MEAN LENGTH OF PLATEAUX OF HIGH SCHOOL SUBJECTS ON PROBLEMS 31, 33, and 35 (TYPE a) FOR THE FOUR FORMS OF EACH PROBLEM

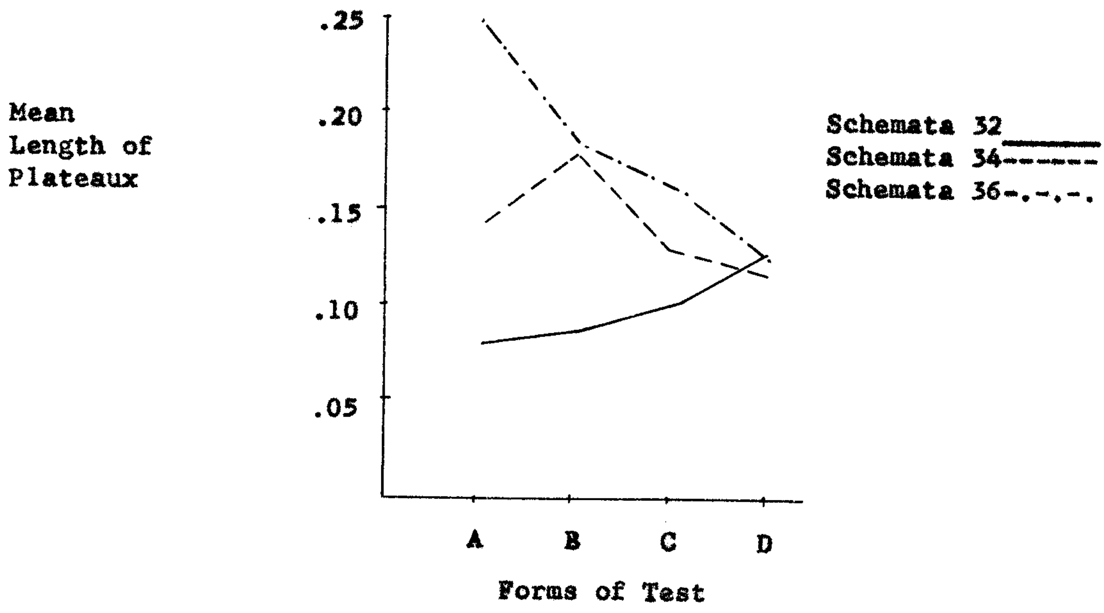

FIGURE 11

MEAN LENGTH OF PLATEAUX OF HIGH SCHOOL SUBJECTS ON PROBLEMS 32, 34, and 36 (TYPE b) FOR THE FOUR FORMS OF EACH PROBLEM

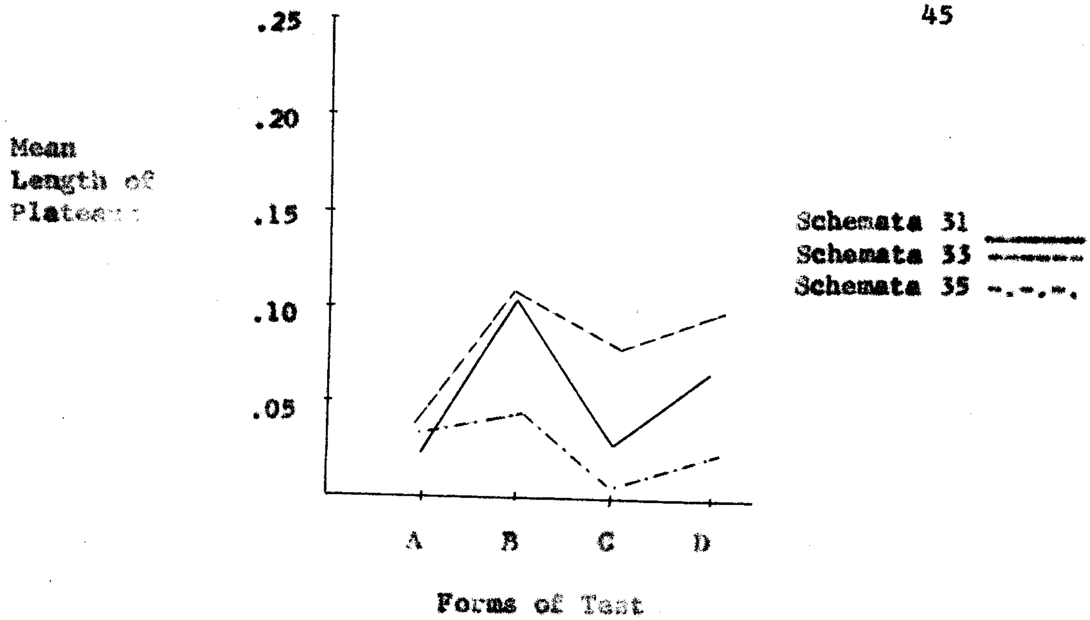

FIGURE 12

MEAN LENGTH OF PLATEAUX OF COLLEGE SUBJECTS ON PROBLEMS 31, 33, and 35 (TYPE a) FOR THE FOUR FORMS OF EACH PROBLEM

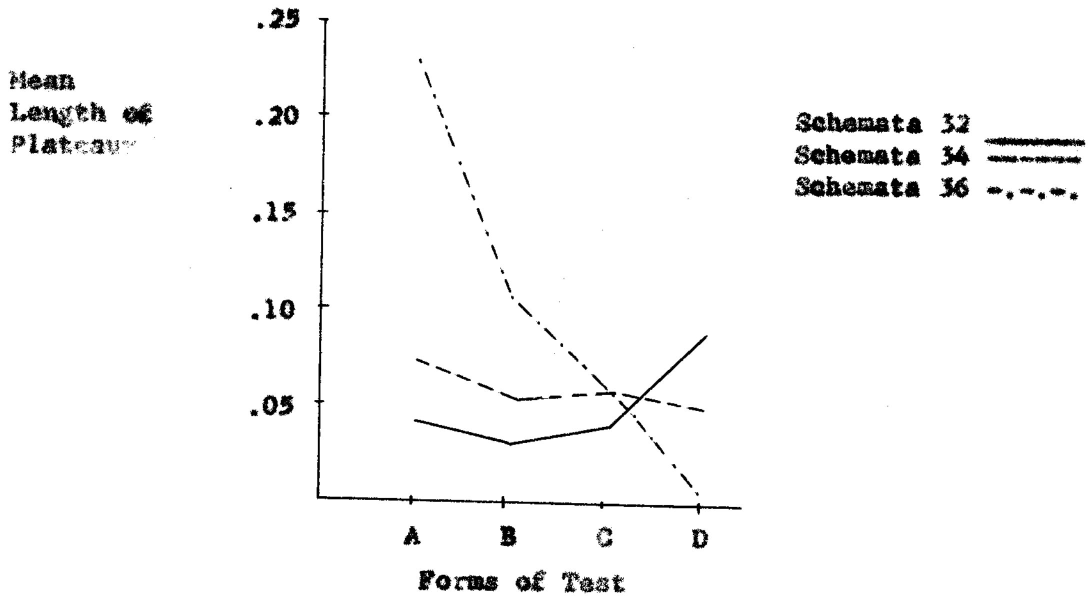

FIGURE 13

MEAN LENGTH OF PLATEAUX OF COLLEGE SUBJECTS ON PROBLEMS 32, 34, and 36 (TYPE b) FOR THE FOUR FORMS OF EACH PROBLEM

c) Performance curves, Group norms and Schemata Norms.

It will be impossible to present the performance curves of every one of the 38 experimental subjects on the 24 problems of the training sessions using both group and schemata norms.

Figures 14 to 19 inclusive present the performance curves according to group norms for the 24 problems that one experimental subject took on the training sessions. The problems are presented in the order that he had taken them. In figures 20 to 25 inclusive the performance curves for the same subject are presented using schemata norms.

Looking at the performance curves for problems 31A,B,C, and D (figures 14 and 20) the differences on the curves can be seen when schemata and group norms are used. In problems 31B and 31D, when scored according to the group norms, the subject received a very high score, his performance curve rapidly increases (figure 14). This means that he was in agreement with the group. Nevertheless, when his performance is scored according to schemata norms, the curves show plateau and very low values. He did not follow any "logical sequence" as defined by the schemata.

In problem 33C (figure 21) the subject shows a good performance according to schemata norms, his curve is increasing rapidly and no plateau is observed. He has followed one "logical sequence" as defined by the schemata norms. When he is scored according to group norms (figure 15) his performance curve increases slowly and he has a low value. He was not in agreement with his group.

Looking at figures 16 and 22 that present the performance curves for problem 35, we see a rapid increase on the curves when he is scored with group norms and also when he is scored with schemata norms. This means that he has followed a "logical sequence" according to the schemata and at the same time, he was in agreement with his group.

Looking at figures 17, 18 and 19 that present the performance curves for problems 32A, B, C, D; 34A, B, C, D; and 36A, B, C, D; using group norms, and at figures 23, 24 and 25 that present the performance curves for the same problems using schemata norms, it can be seen that in all but two of these problems he has a better performance curve when using schemata norms than when using group norms.

In summary, it can be concluded that a performance curve using group norms will not tell us how the subject has solved the problem but how he is in agreement with the other subjects in the group. The performance curve using schemata norms will tell us how the subject has approached the problem. If he has used a "logical sequence", no plateaux will appear on the performance curve and his score and performance curve will be the same regardless of the group to which he belongs.

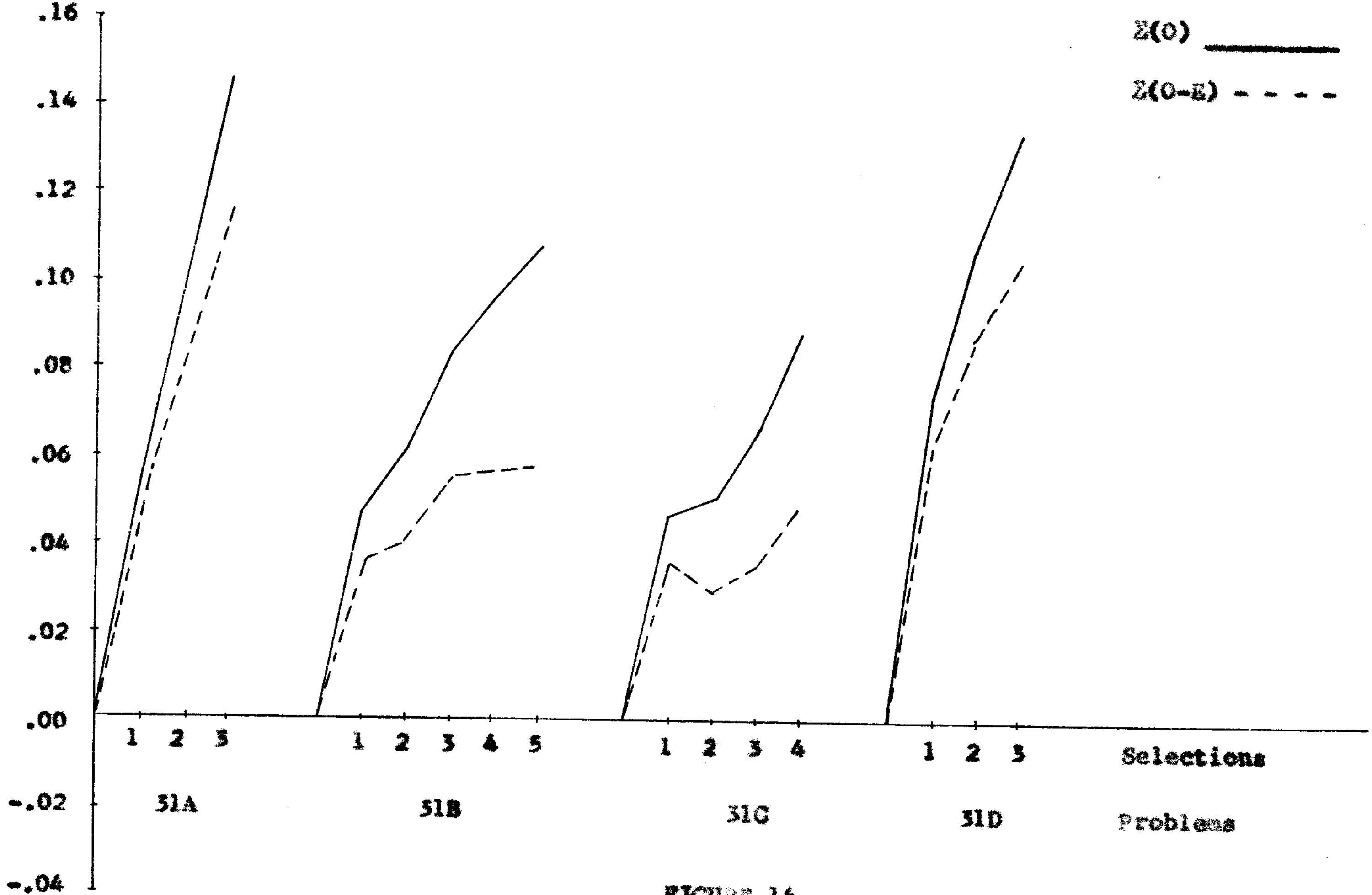

FIGURE 14

PERFORMANCE CURVES BASED ON GROUP NORMS FOR AN EXPERIMENTAL SUBJECT ON PROBLEMS 31A, B, C, D OF THE TRAINING SESSIONS

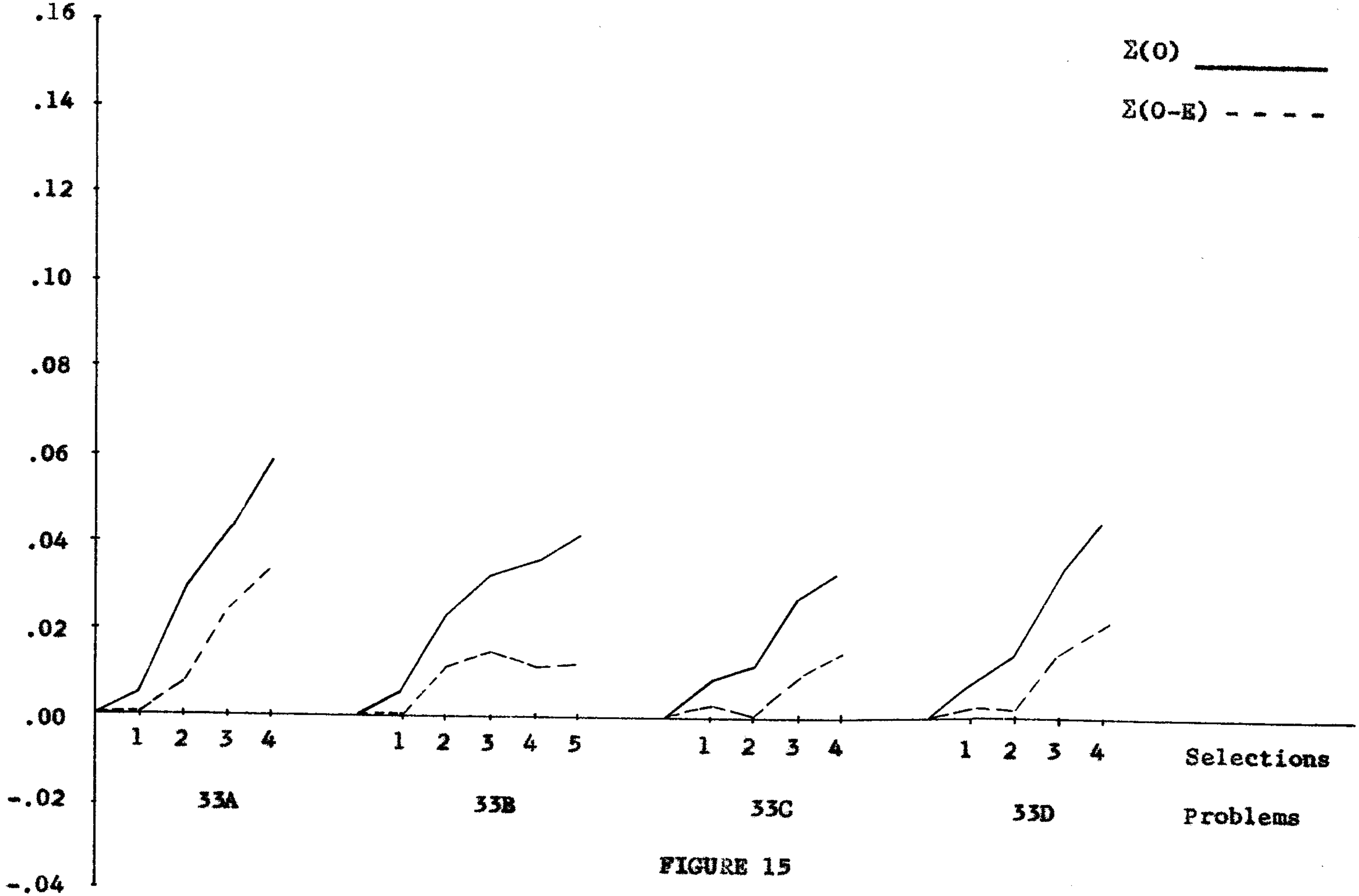

FIGURE 15

PERFORMANCE CURVES BASED ON GROUP NORMS FOR AN EXPERIMENTAL SUBJECT ON PROBLEMS 33A, B, C, D OF THE TRAINING SESSIONS

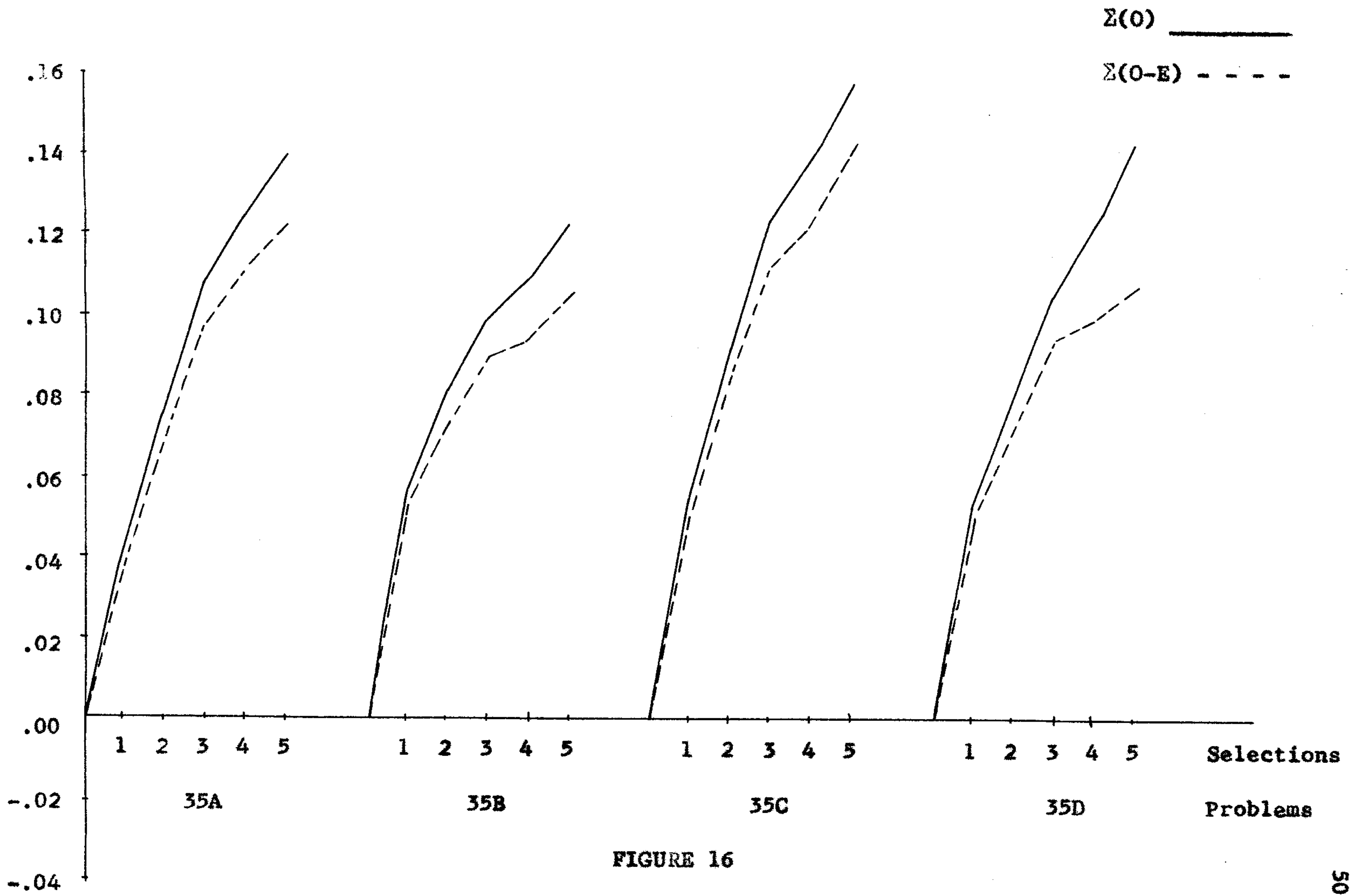

FIGURE 16

PERFORMANCE CURVES BASED ON GROUP NORMS FOR AN EXPERIMENTAL SUBJECT ON PROBLEMS 35A, B, C, D OF THE TRAINING SESSIONS

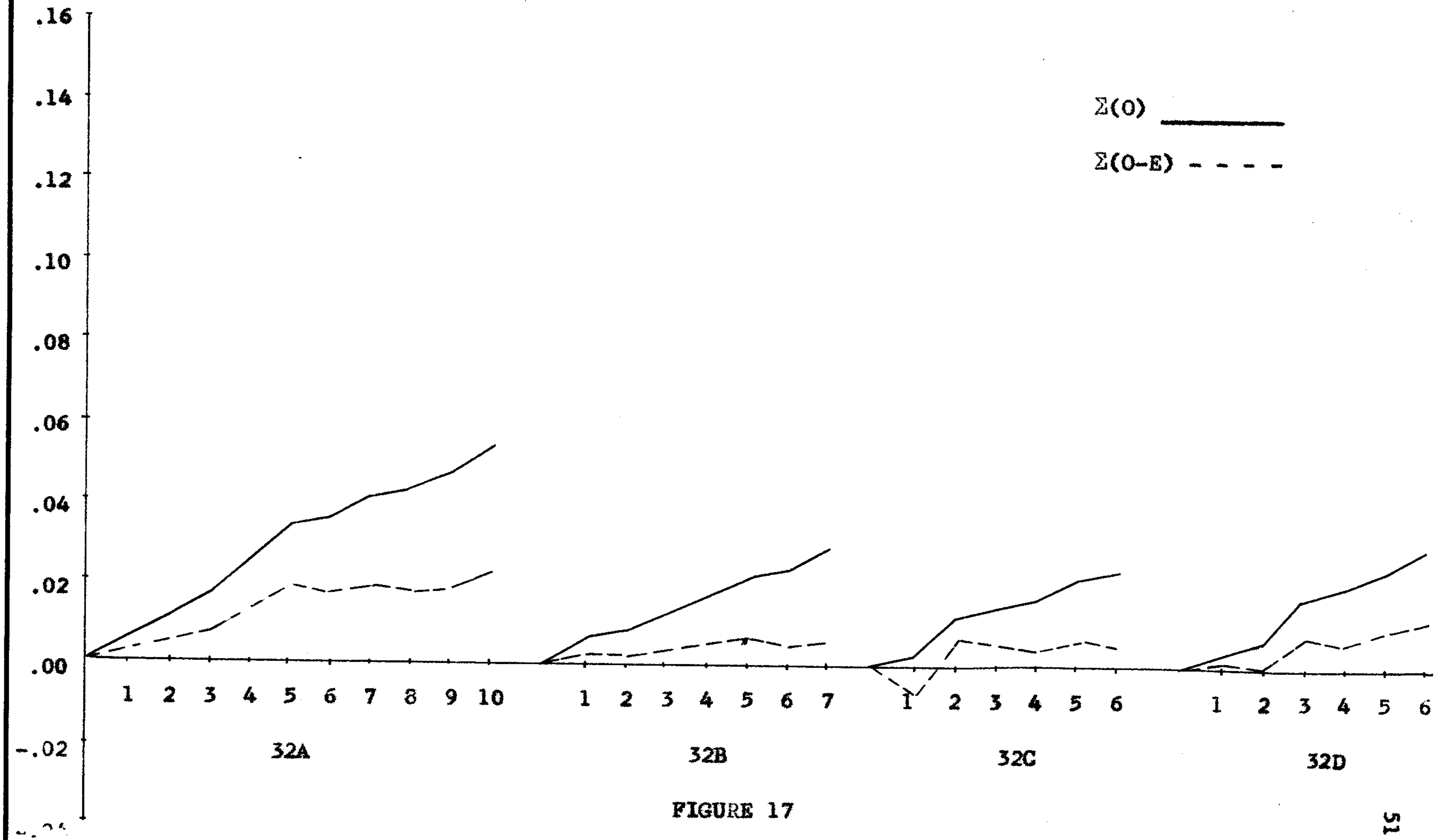

FIGURE 17

PERFORMANCE CURVES BASED ON GROUP NORMS FOR AN EXPERIMENTAL SUBJECT ON PROBLEMS 32A, B, C, D OF THE TRAINING SESSION

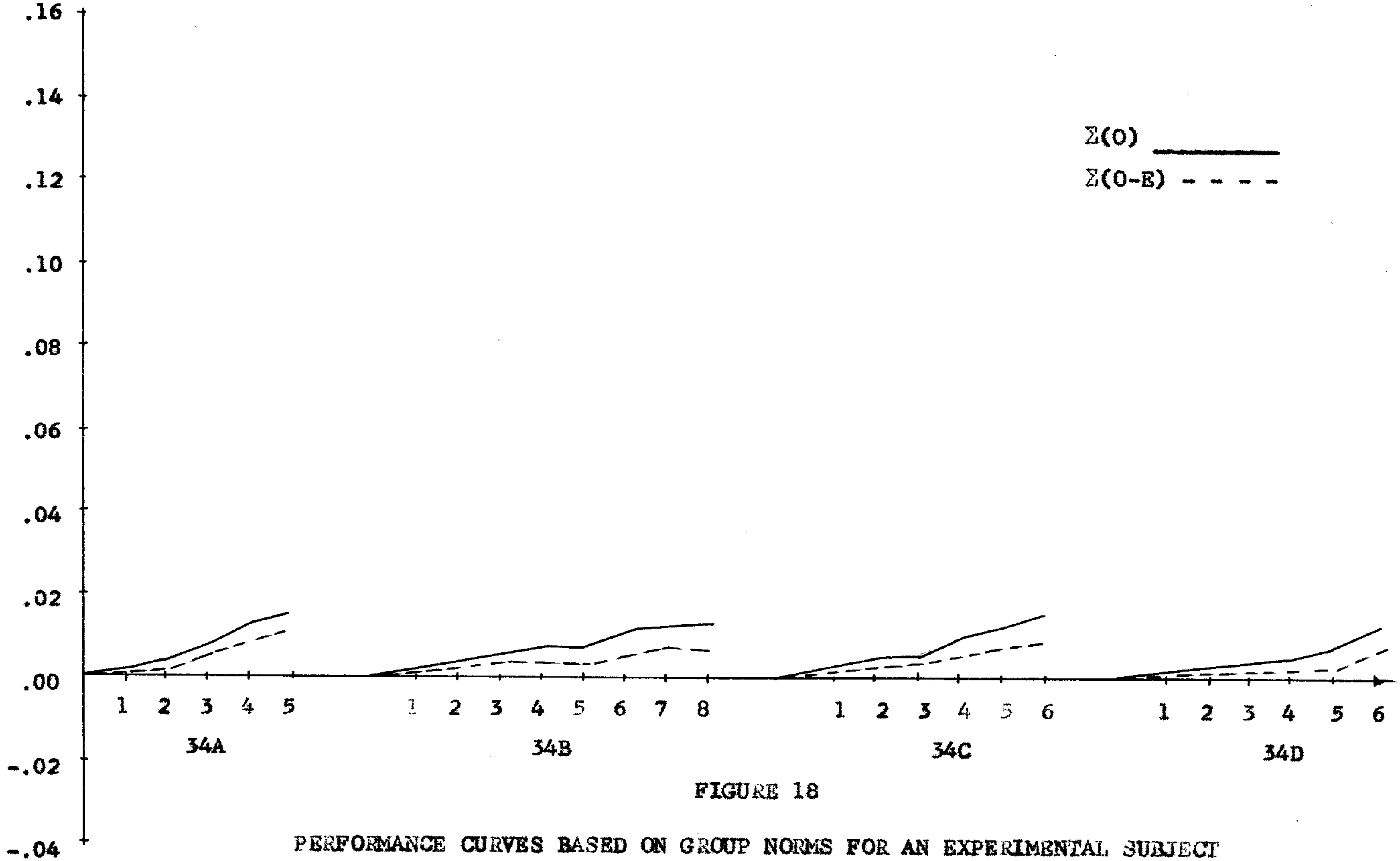

FIGURE 18

PERFORMANCE CURVES BASED ON GROUP NORMS FOR AN EXPERIMENTAL SUBJECT
ON PROBLEMS 34A, B, C, D OF THE TRAINING SESSIONS

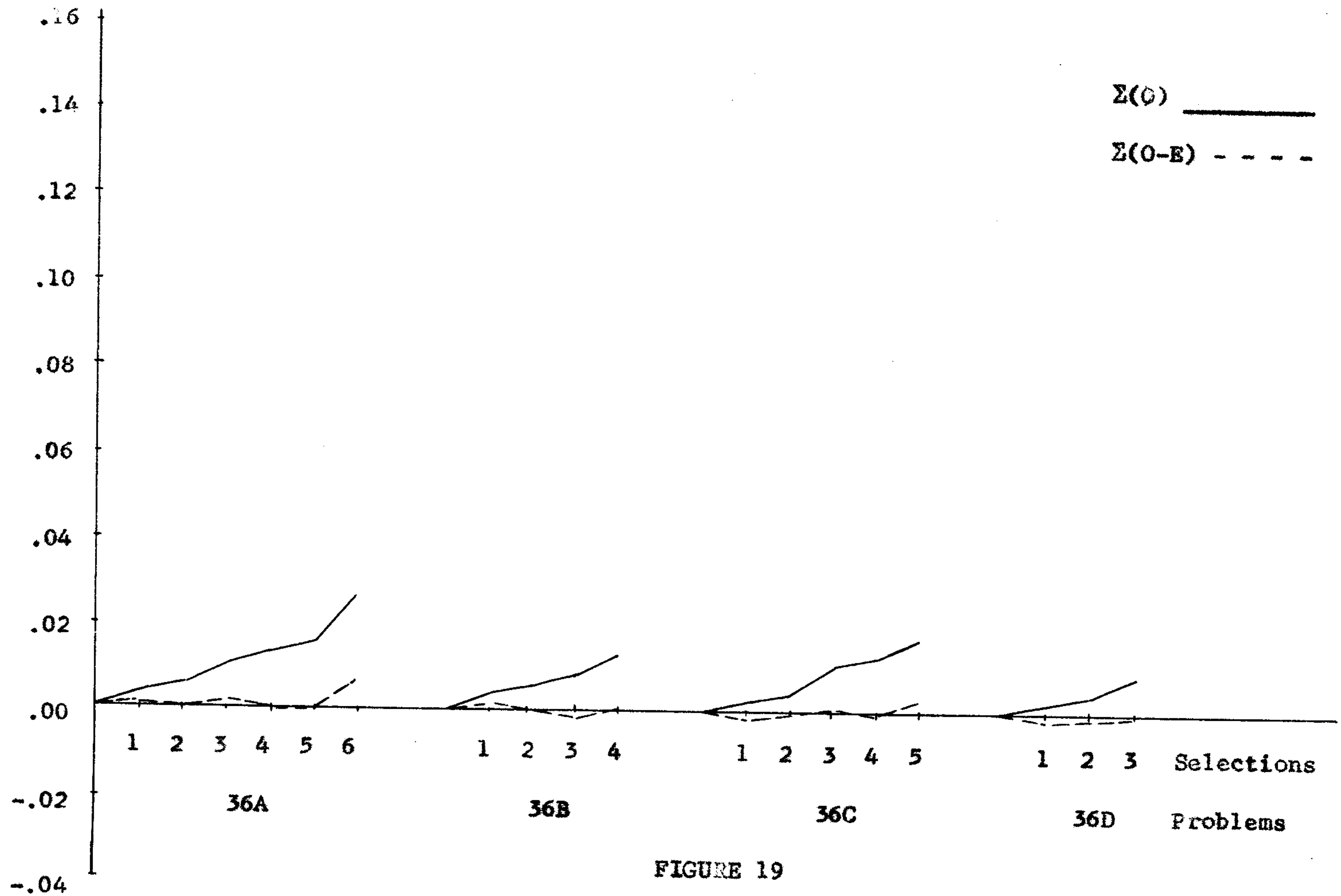

FIGURE 19

PERFORMANCE CURVES BASED ON GROUP NORMS FOR AN EXPERIMENTAL SUBJECT ON PROBLEMS 36A, B, C, D OF THE TRAINING SESSIONS

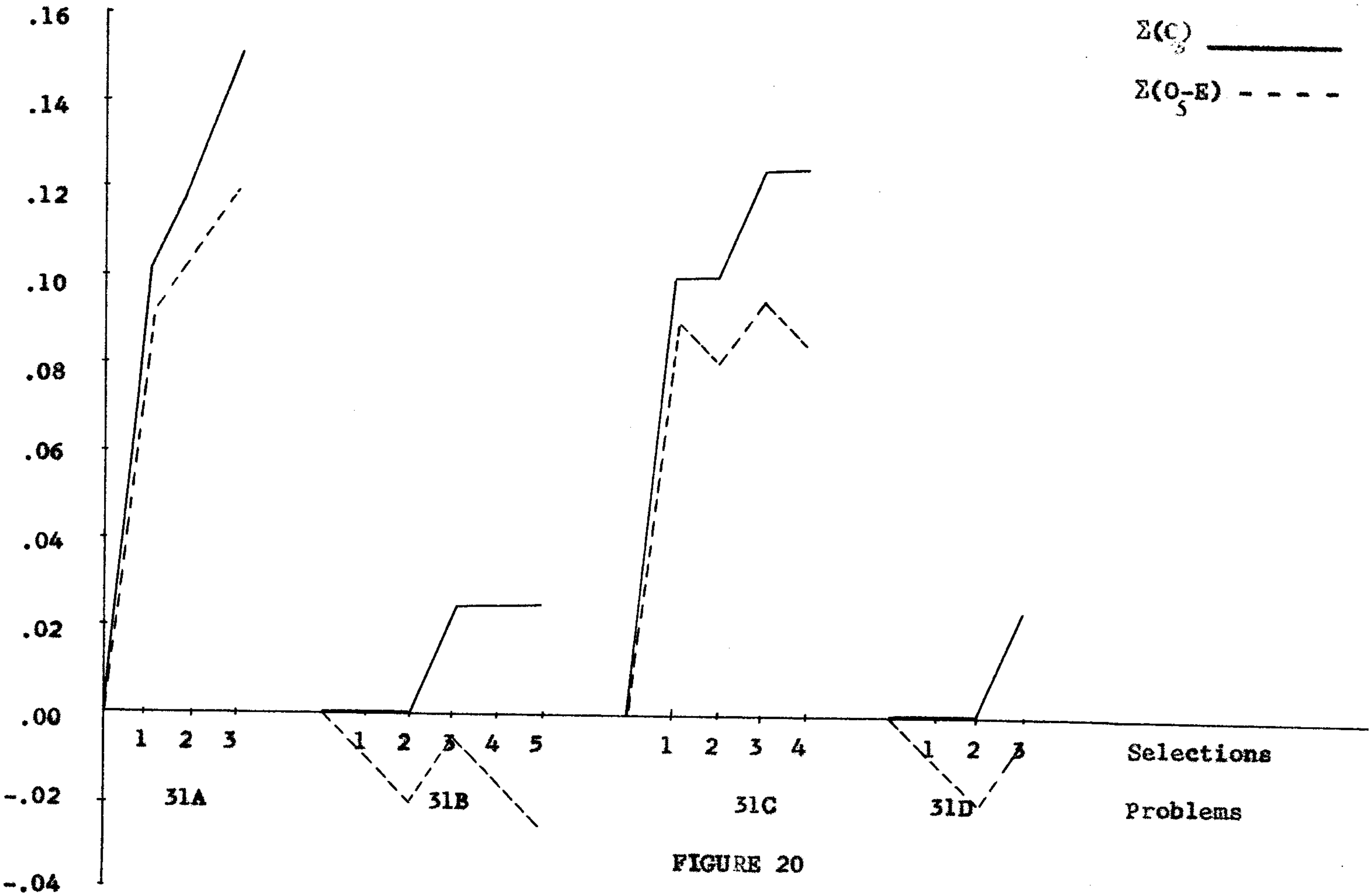

FIGURE 20

PERFORMANCE CURVES BASED ON SCHEMATA NORMS FOR AN EXPERIMENTAL SUBJECT ON PROBLEMS 31A, B, C, D OF THE TRAINING SESSIONS

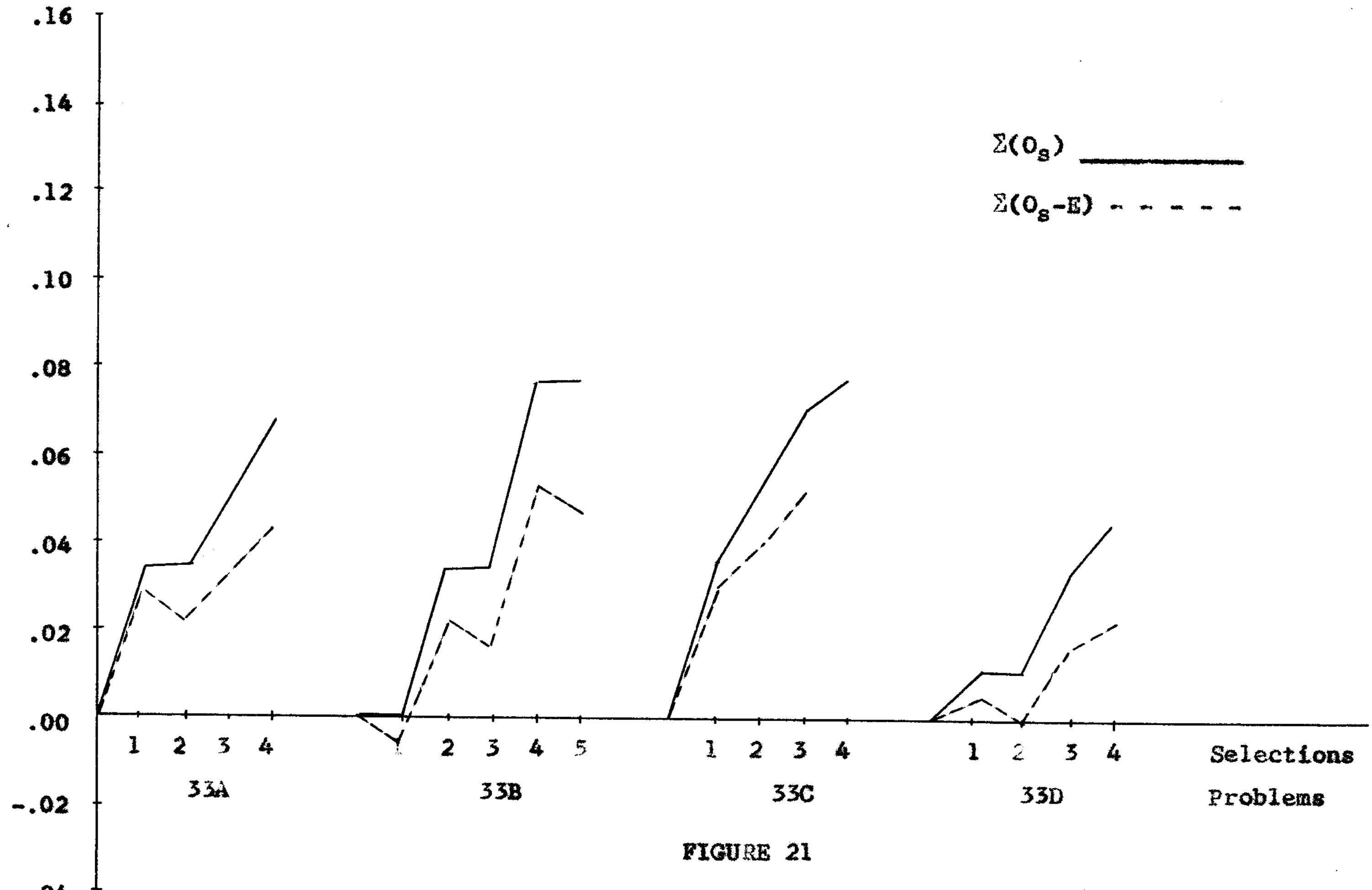

FIGURE 21

PERFORMANCE CURVES BASED ON SCHEMATA NORMS FOR AN EXPERIMENTAL SUBJECT ON PROBLEMS 33A, B, C, D OF THE TRAINING SESSIONS

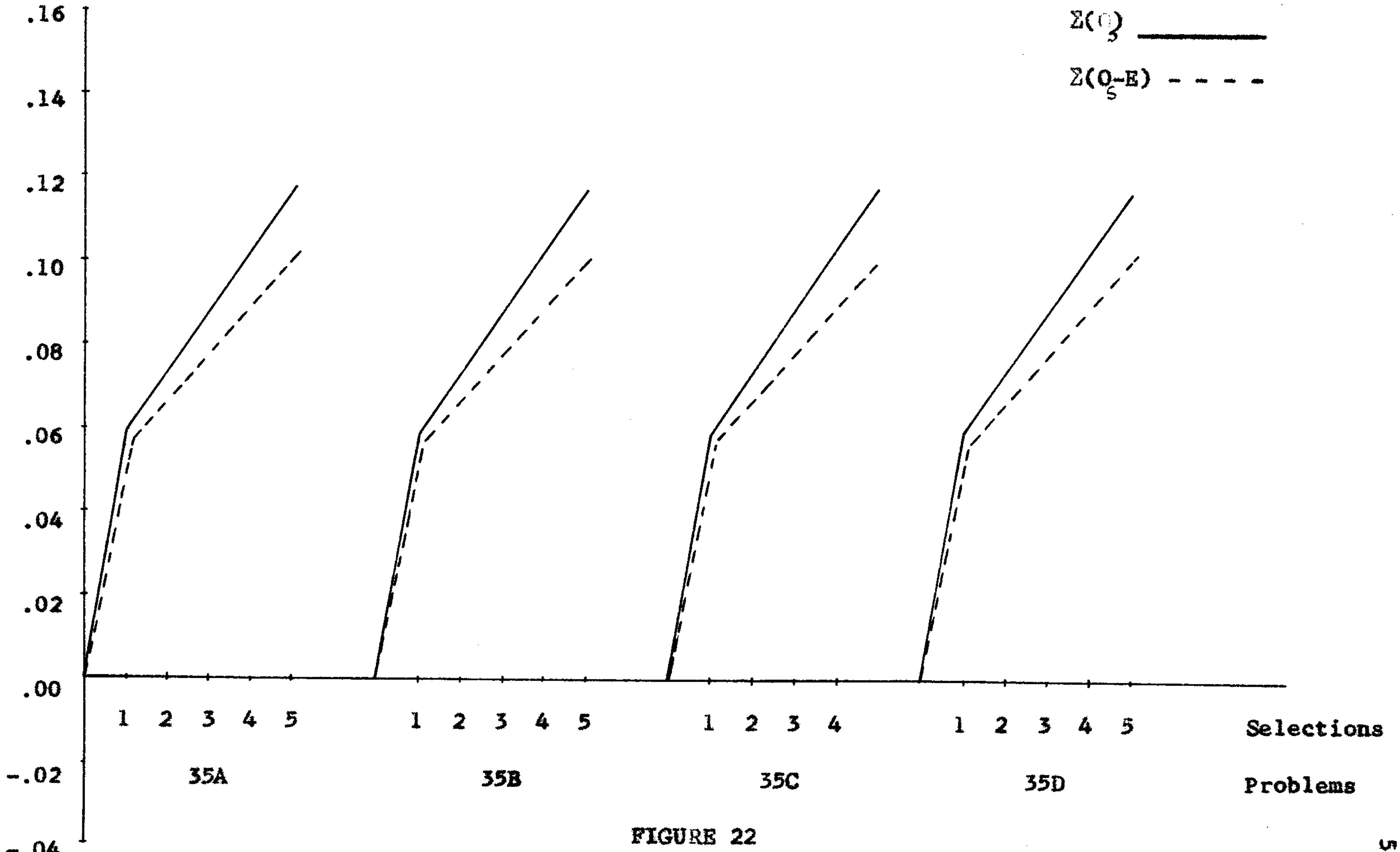

FIGURE 22

PERFORMANCE CURVES BASED ON SCHEMATA NORMS FOR AN EXPERIMENTAL SUBJECT
ON PROBLEMS 35A, B, C, D OF THE TRAINING SESSIONS

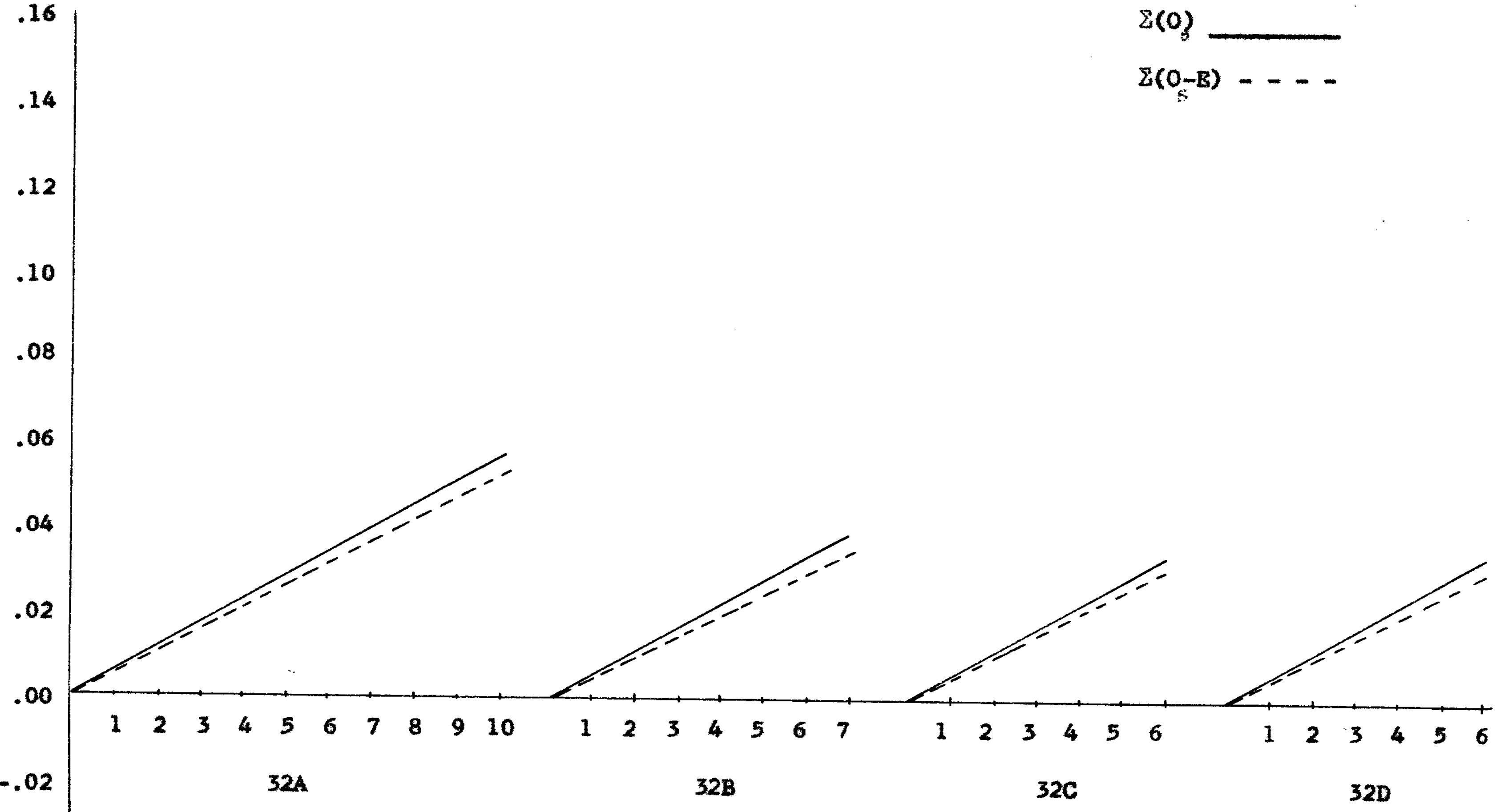

FIGURE 23

PERFORMANCE CURVES BASED ON SCHEMATA NORMS FOR AN EXPERIMENTAL SUBJECT ON PROBLEMS 32A, B, C, D OF THE TRAINING SESSIONS

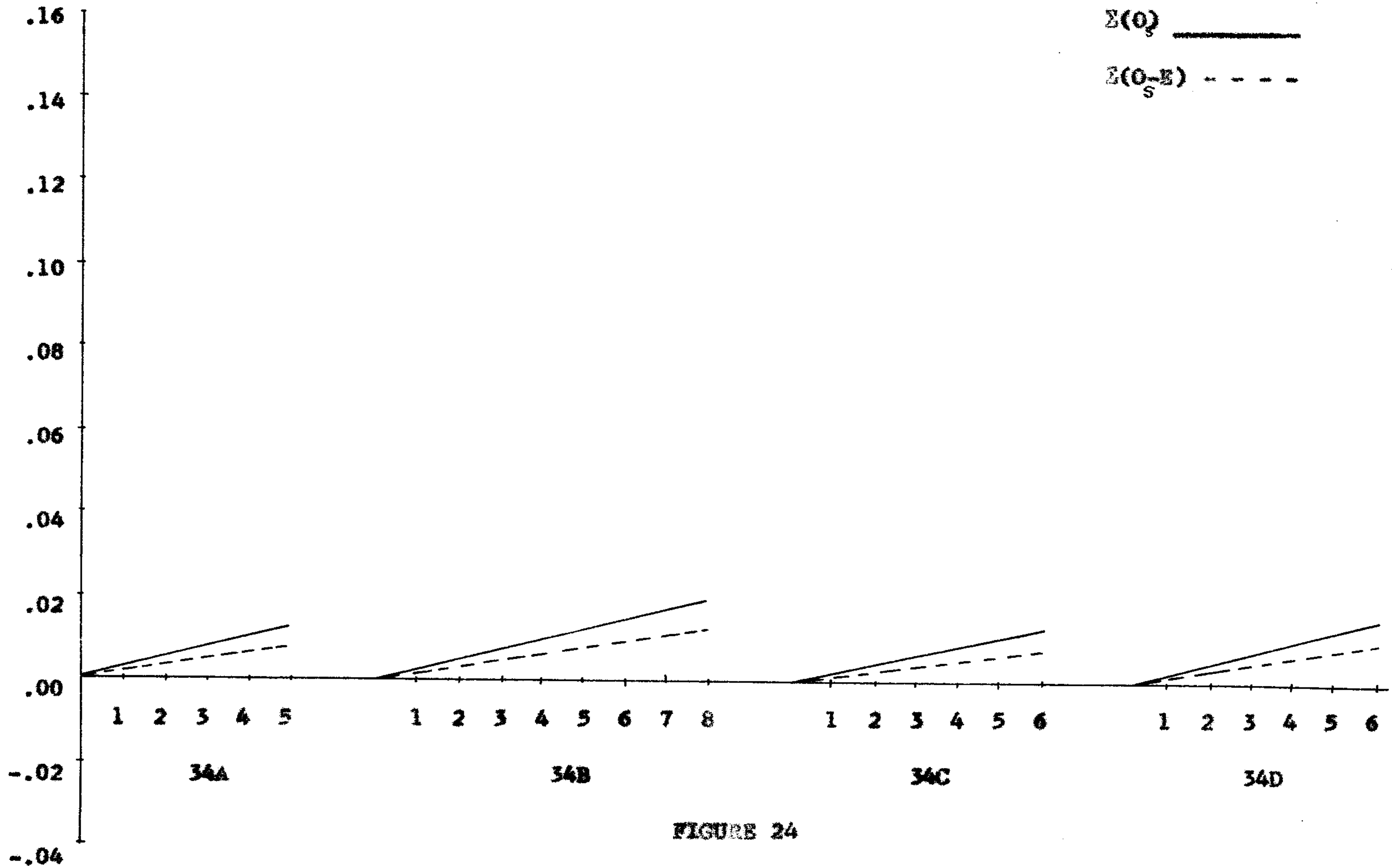

FIGURE 24

PERFORMANCE CURVES BASED ON SCHEMATA NORMS FOR AN EXPERIMENTAL SUBJECT ON PROBLEMS 34A, B, C, D OF THE TRAINING SESSIONS

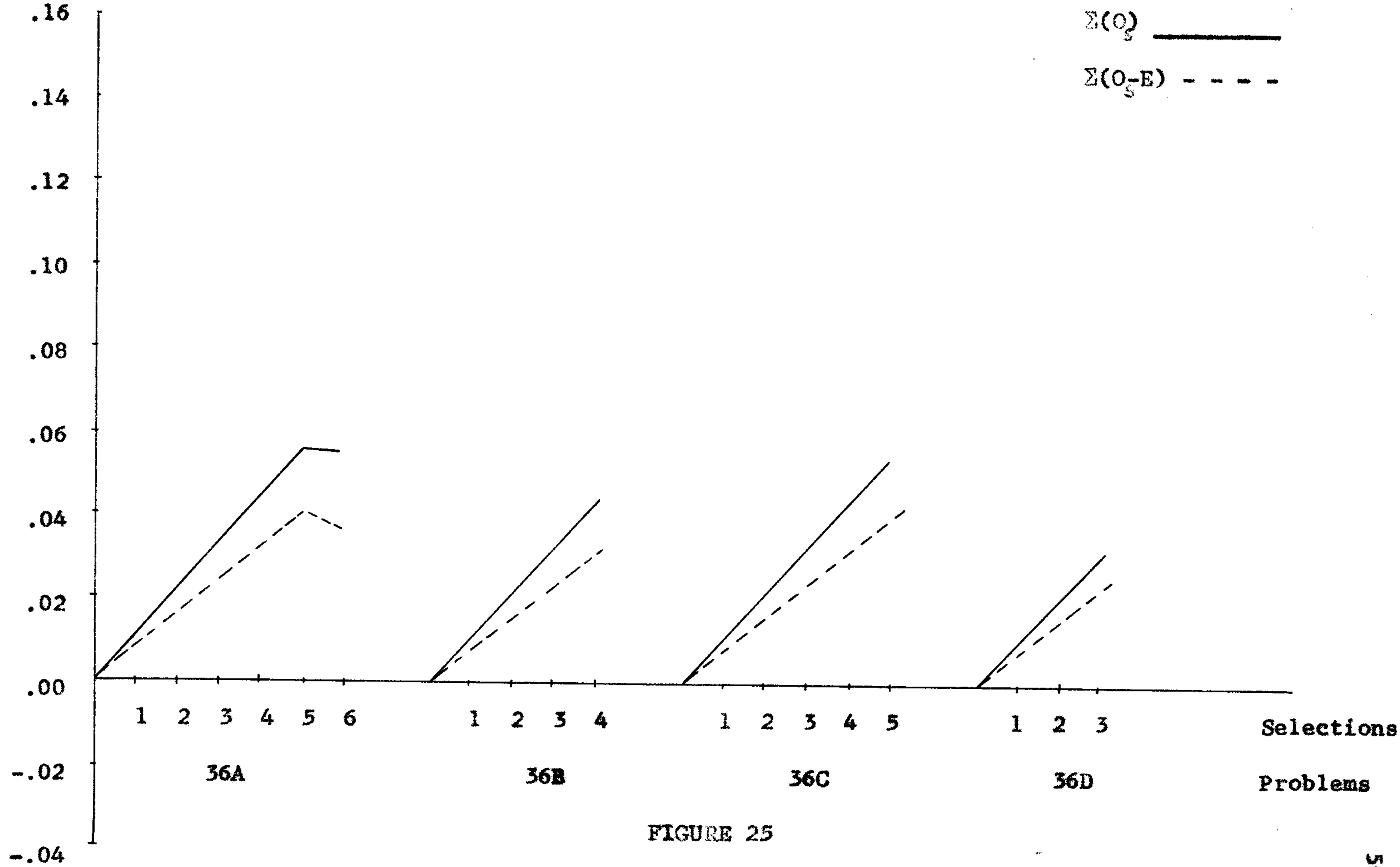

FIGURE 25

PERFORMANCE CURVES BASED ON SCHEMATA NORMS FOR AN EXPERIMENTAL SUBJECT ON PROBLEMS 36A, B, C, D OF THE TRAINING SESSIONS

2. College versus high school students.

a) Length of plateaux.

One of the aims of this study was to see the influence that educational level has on the performance of these types of problems. For this reason the college students as a group were compared with the high school students on the 24 problems used in the training sessions. This comparison was done using length of plateaux calculated from the schemata norms.

The mean, standard deviation, and "t" values for each one of the 24 problems of the training sessions for high school and college students are presented in table 11. The high school students show on all the problems longer plateaux than the college students. The "t" values (one tail test) are significant at the .05 level or more on 19 out of the 24 problems.

From these results it can be concluded that the college students, in general, approach the problems in a "more logical" way than the high school students.

TABLE XI

MEAN, AND STANDARD DEVIATIONS OF LENGTH OF PLATEAUX, NUMBER OF SUBJECTS AND "t" VALUES FOR EACH ONE OF THE 24 PROBLEMS OF THE TRAINING SESSIONS FOR THE EXPERIMENTAL SUBJECTS IN HIGH SCHOOL AND COLLEGE

Problems		High School			College			
		M	σ	N	M	σ	N	"t" Values
Type a	31A	1.42	1.70	19	1.05	1.10	19	.80
	B	4.42	2.21	19	4.11	1.97	19	.46
	C	3.74	2.71	19	1.16	1.39	19	3.69***
	D	4.11	2.12	19	2.68	.86	19	2.71**
	33A	5.58	2.66	19	1.79	1.54	19	5.37***
	B	6.53	2.37	19	4.26	2.20	19	3.06**
	C	5.32	2.97	19	3.32	2.62	19	2.20*
	D	5.32	2.49	19	3.89	1.89	19	1.99*
	35A	2.00	2.43	19	1.21	2.07	19	1.08
	B	3.95	4.39	19	1.74	2.12	19	1.98*
	C	3.37	3.63	19	.47	1.39	19	3.25**
	D	3.26	3.49	19	.95	1.54	19	2.64**
Type b	32A	3.37	2.81	19	1.89	1.84	19	1.99*
	B	3.53	3.33	19	1.37	2.01	19	2.42*
	C	4.05	2.98	19	1.79	2.28	19	2.63**
	D	5.11	3.21	19	3.53	3.14	19	1.53
	34A	5.89	6.40	19	3.00	3.74	19	1.70*
	B	7.32	5.78	19	2.21	3.07	19	3.40**
	C	5.26	5.98	19	2.26	2.83	19	1.98*
	D	4.79	4.54	19	2.16	2.76	19	2.16*
	36A	10.00	4.33	19	9.26	4.83	19	.50
	B	7.47	5.08	19	4.53	4.74	19	1.84*
	C	6.53	5.58	19	2.63	4.43	19	2.39*
	D	5.05	5.54	19	.26	.71	19	3.74***

* $p < .05$
** $p < .01$
*** $p < .001$

B. Pre and post-testing sessions.

1. Control versus experimental subjects

a) Schemata norms:

Table 12 presents the mean differences, the standard deviations of differences, and "t" values for differences between experimental and control subjects on the accumulative score for every problem administered during the pre and post-testing sessions for the high school and college students.

Comparing experimental and control subjects on the accumulative score (schemata norms) in problems 1, 19, and 25 which were administered in the pre and post-testing sessions, no significant differences are found neither for high school nor for college students. It is possible that memory has had an influence on the performance of the experimental subjects in the second administration of these problems. For here it appears that memory of the first administration has overcome the effect of the training between the administrations.

Problems 31D' and 35B' have the same schemata and content as the one used in the training sessions. The differences between control and experimental subjects are significant at the .001 level for problem 31D' with both the high school and college students; and at the .01 level for problem 35B' with college students. For problem 35B' there is no significant difference between control and experimental high school subjects.

In problem 32F there is no significant difference between control and experimental subjects. The content of problem 32F was not similar to the one used in the training sessions. Problem 36F has the same schemata and content as the one used in the training sessions; the M_D of the accumulative score is significant at the .001 level for college students and at .01 level for high school students.

Problems 26 and 41A were new problems with different schemata than the ones used in the training sessions. There is no significant difference between control and experimental high school and college students.

In summary, these results seem to indicate that when the problems have the same schemata and content as the ones used in the training sessions, the differences between experimental and control subjects on the "logical" way of approaching a problem are significant. But, introducing a change in the schemata or in the content, the subjects with training seem to approach the problem in as similar a manner as the subjects without training do when judged by the accumulative score obtained according to the schemata norms.

TABLE XII

MEAN DIFFERENCES, STANDARD DEVIATIONS OF DIFFERENCES
BETWEEN EXPERIMENTAL AND CONTROL SUBJECTS
ON THE ACCUMULATIVE SCORES (SCHEMATA NORMS),
NUMBER OF SUBJECTS AND "t" VALUES FOR EACH ONE OF THE PROBLEMS
OF THE PRE-TESTING AND POST-TESTING SESSIONS
OF HIGH SCHOOL AND COLLEGE STUDENTS

		High School				College			
Problems		M_D	σ_D	N	"t"	M_D	σ_D	N	"t"
Pre-	1	-.00413	.01774	19	-1.01	-.00061	.02572	19	- .10
Testing	19	.00754	.02673	19	1.23	-.00666	.02475	19	-1.17
	25	.00371	.02239	19	.72	.00556	.02055	19	1.18
Post-	1	.00255	.02676	19	.42	.00061	.01648	19	.16
Testing	19	.00710	.02963	19	1.04	.00380	.00804	19	.47
	25	-.00657	.02357	19	-1.21	.00101	.02303	19	.19
Type a	31D'	.04868	.05224	19	4.06***	.05921	.06294	19	4.10***
	35B'	.01779	.04901	19	1.58	.03326	.04953	19	2.95**
Type b	32F	-.00010	.00082	19	- .53	-.00002	.00068	19	- .11
	36F	.00280	.00375	19	3.26**	.00422	.00265	19	6.94***
New	26	.01053	.03969	19	1.16	-.00203	.04742	19	- .18
Problems	41A	-.00876	.03787	19	-1.01	-.00643	.05007	19	- .56

* $p < .05$
** $p < .01$
*** $p < .001$

b) Length of plateaux:

By inspection of the performance curves using schemata norms (figures 20 to 33 inclusive), it can be seen that there are moments in the solution of the problem when no improvement is observed. This means that the subject had selected a useless question, a question that has a score of zero. Observing the performance curves of every subject in all the problems, it is possible to know the length of plateaux that each subject has in every problem. In table 13 the mean differences, standard deviation of differences, number of subjects, and "t" values are given for the differences between control and experimental high school and college subjects for the problems of the pre and post-testing sessions.

When comparing experimental and control subjects in problems 1, 19, and 25 that were used in the pre and post-testing sessions, no differences on the length of plateaux is observed.

Problems 31D' and 35B' have the same schemata and content as the one used in the training sessions; the differences between control and experimental are significant at the .01 level or more.

Problem 32F has the same figure but different content than the one used in the training sessions; the differences are not significant. Problem 36F has the same schemata and content as the one used in the training sessions; the differences between control and experimental are significant at .001 level for the college students and at the .01 level for the high school students.

Problems 26 and 41A were new problems. The differences are in the expected direction, but a .05 level of significance was reached on problem 26 only with the college students.

In summary, by the study of length of plateaux comparing control and experimental subjects, it can be concluded that when control and experimental subjects know the problem there is no significant difference in the way that they approach the problem. But, there is a significant difference when the problem has the same schemata and content as the one used in the training sessions. When the problems have a different schemata or content than the one used in the training sessions, the subjects with training always approach the problem in a more "logical" way than the subjects without training, nevertheless the differences do not always reach a level of significance.

Comparing these results with the conclusions on accumulative score, it can be seen that, in general, they are similar. Nevertheless, the study of length of plateaux seems to be a more sensitive technique than the study of the accumulative score. The accumulative score is obtained by accumulating the score corresponding to every question that the subject has asked. If the subject asked useless questions, he received a score of zero; yet he is not punished by the number of useless questions he asked. However, the useless questions are taken into consideration in the study of length of plateaux.

TABLE XIII

MEAN DIFFERENCES, STANDARD DEVIATIONS OF DIFFERENCES BETWEEN CONTROL AND EXPERIMENTAL SUBJECTS ON THE LENGTH OF PLATEAUX, NUMBER OF SUBJECTS AND "t" VALUES FOR EACH ONE OF THE PROBLEMS OF THE PRE-TESTING AND POST-TESTING SESSIONS OF HIGH SCHOOL AND COLLEGE STUDENTS

		High School				College			
Problems		M_D	σ_D	N	"t"	M_D	σ_D	N	"t"
Pre-Testing	1	.36842	2.27597	19	.71	- .10526	1.37246	19	- .33
	19	.63158	3.32788	19	.83	.36842	2.47536	19	.65
	25	1.05263	5.70755	19	.80	1.63158	4.01589	19	1.77
Post-Testing	1	- .10526	1.99723	19	- .23	- .05263	.60469	19	- .38
	19	- .15789	3.82874	19	- .18	.63158	2.71856	19	1.01
	25	- .84210	3.61667	19	-1.01	.36842	1.92519	19	..83
Type a	31D'	1.73684	2.57196	19	2.94**	2.42105	2.43474	19	4.33***
	35B'	2.63158	3.75865	19	3.05**	3.31579	4.67977	19	3.09**
Type b	32F	.57895	3.99099	19	.63	.31579	3.22902	19	.43
	36F	4.89474	7.45438	19	2.86**	8.15579	5.14284	19	6.91***
New Problems	26	.68421	2.86637	19	1.04	1.36842	2.67956	19	2.23*
	41A	.78947	2.14179	19	1.61	1.05263	3.03443	19	1.51

* $p < .05$
** $p < .01$
*** $p < .001$

c) Performance curves:

It is impossible to present the performance curves for every subject on all the problems they have taken. The performance curves for a control-experimental pair (schemata norms) are presented in figures 26 to 33 inclusive. This pair was selected not because it emphasized the differences between control and experimental subject, but because, according to the author, it is one of the typical cases.

The performance curves for problem 1, pre and post-testing, for the control-experimental pair presented in figure 26 show a plateau on the curve of the control subject in the post-testing sessions.

In figures 27 and 28 the performance curves for problem 19 in the pre and post-testing sessions show higher values for the experimental subject than for the control subject and no plateaux on the curve of the experimental subject on the post-testing session.

In the performance curves of problem 25 (figure 29) the experimental subject shows a higher value on the pre-testing session but longer plateaux than the control subject. The performance curve for the control subject shows no plateaux and higher values than the performance curve of the experimental subject in the post-testing session.

The performance curves for problems 31D' and 35B' (figure 30) show a "better" performance for the experimental than for the control subject. The experimental subject has higher values and no plateaux at all, while the control subject has lower values and longer plateaux.

Looking at figures 31 and 32 for the performance curves in problems 32F and 36F, the experimental subject shows no plateaux at all, while the control subject shows 6 and 12 plateaux respectively which are the maximum possible length of plateaux for these two problems.

Figure 33 shows higher value and longer length of plateaux for the control than for the experimental subject on problem 26. In problem 41A the experimental subject reached a higher value but also shows a plateaux on the performance curve.

In summary, the performance curves of the control-experimental pair presented here show no clear differentiation between the two subjects on the performance curves of problems 1, 19, and 25 in the pre-testing sessions. When the same problems 1, 19, and 25 were administered at the end of the experiment, the experimental subjects had a "better" performance on problems 1 and 19. In problem 25 the control subject had a "better" performance than the experimental subject.

Looking at the performance curves for problems 31D', 35B', 32F and 36F, a clear differentiation is demonstrated. The experimental subject has no plateaux at all on the performance curves. This means that he has solved the problems using a "logical" sequence of questions. The control subject showed a large number of plateaux on the performance curves of these problems. This means that he has solved the problems using a "nonlogical" sequence according to the schemata norms. Regarding the new problems 26 and 41A no clear differentiation between the performance of the two subjects is found.

The performance curves of just one control-experimental pair was selected among the 38 control-experimental pairs. It is not possible to say that the performance curves of all the control-experimental subjects are like the ones presented here; but, in general, they follow the trend explained above.

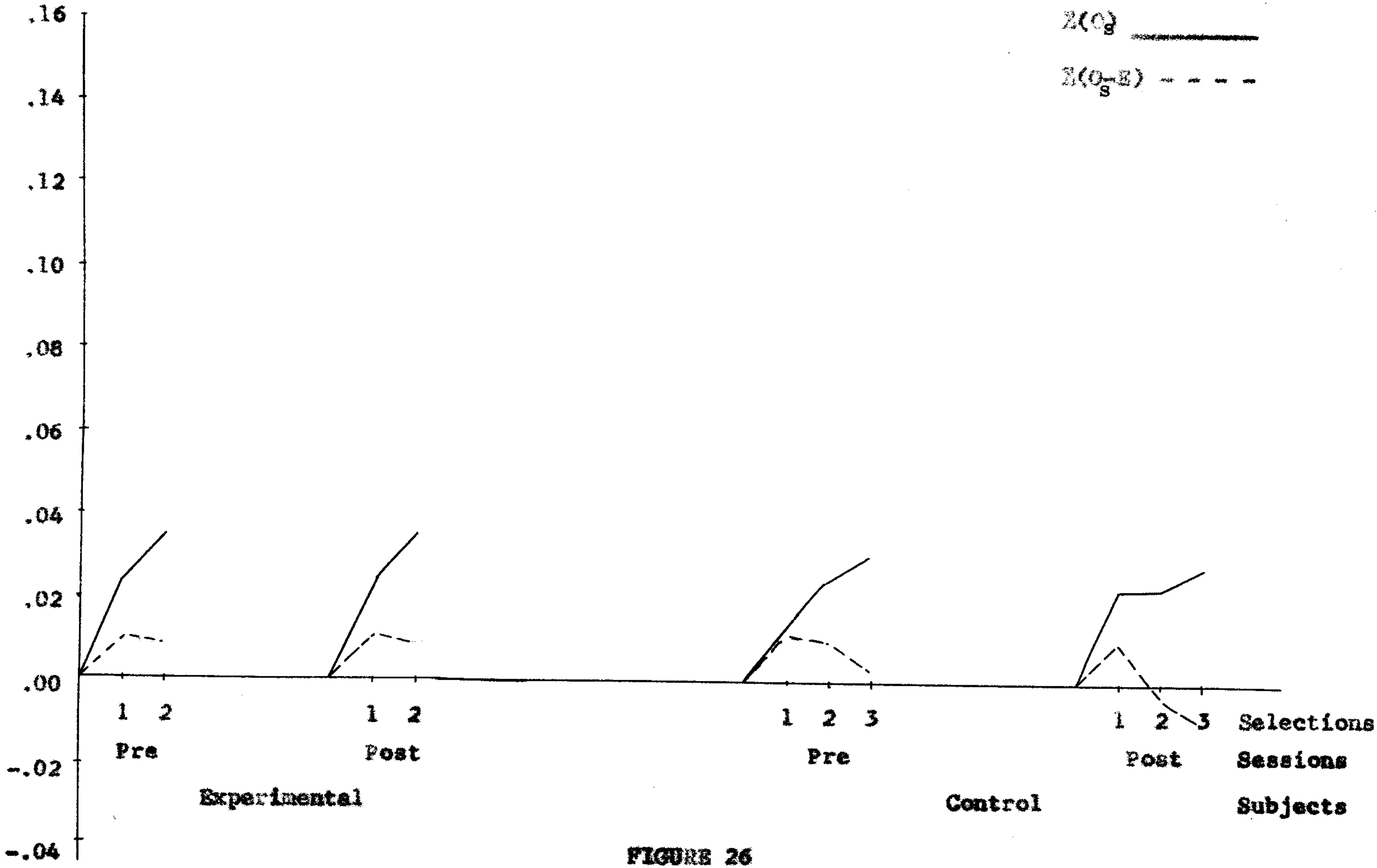

FIGURE 26

PERFORMANCE CURVES FOR A CONTROL-EXPERIMENTAL PAIR (SCHEMATA NORMS)
FOR PROBLEM 1 PRE- and POST-TESTING SESSIONS

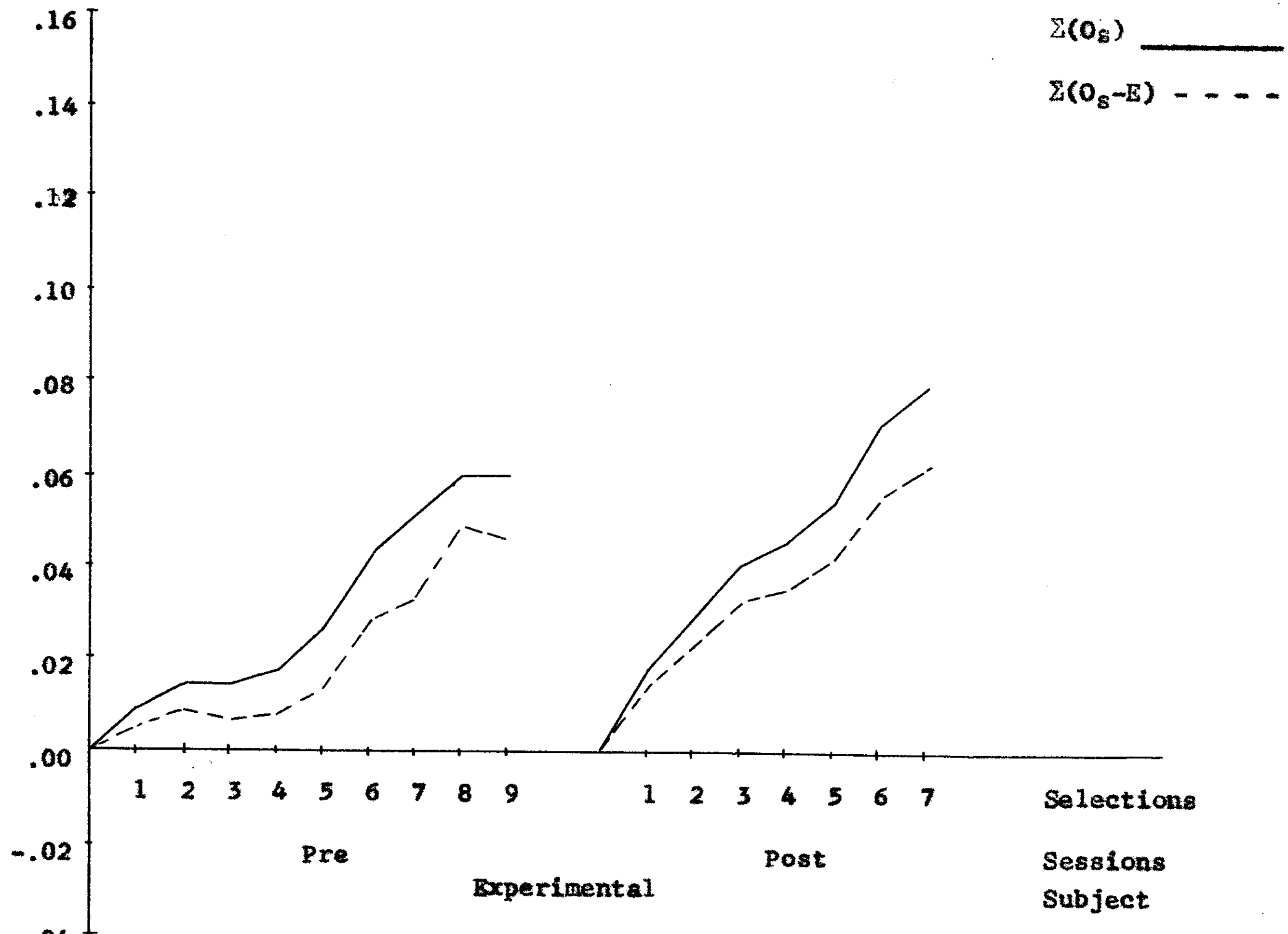

FIGURE 27

PERFORMANCE CURVES FOR A EXPERIMENTAL SUBJECT (SCHEMATA NORMS)
FOR PROBLEM 19 PRE AND POST-TESTING SESSIONS

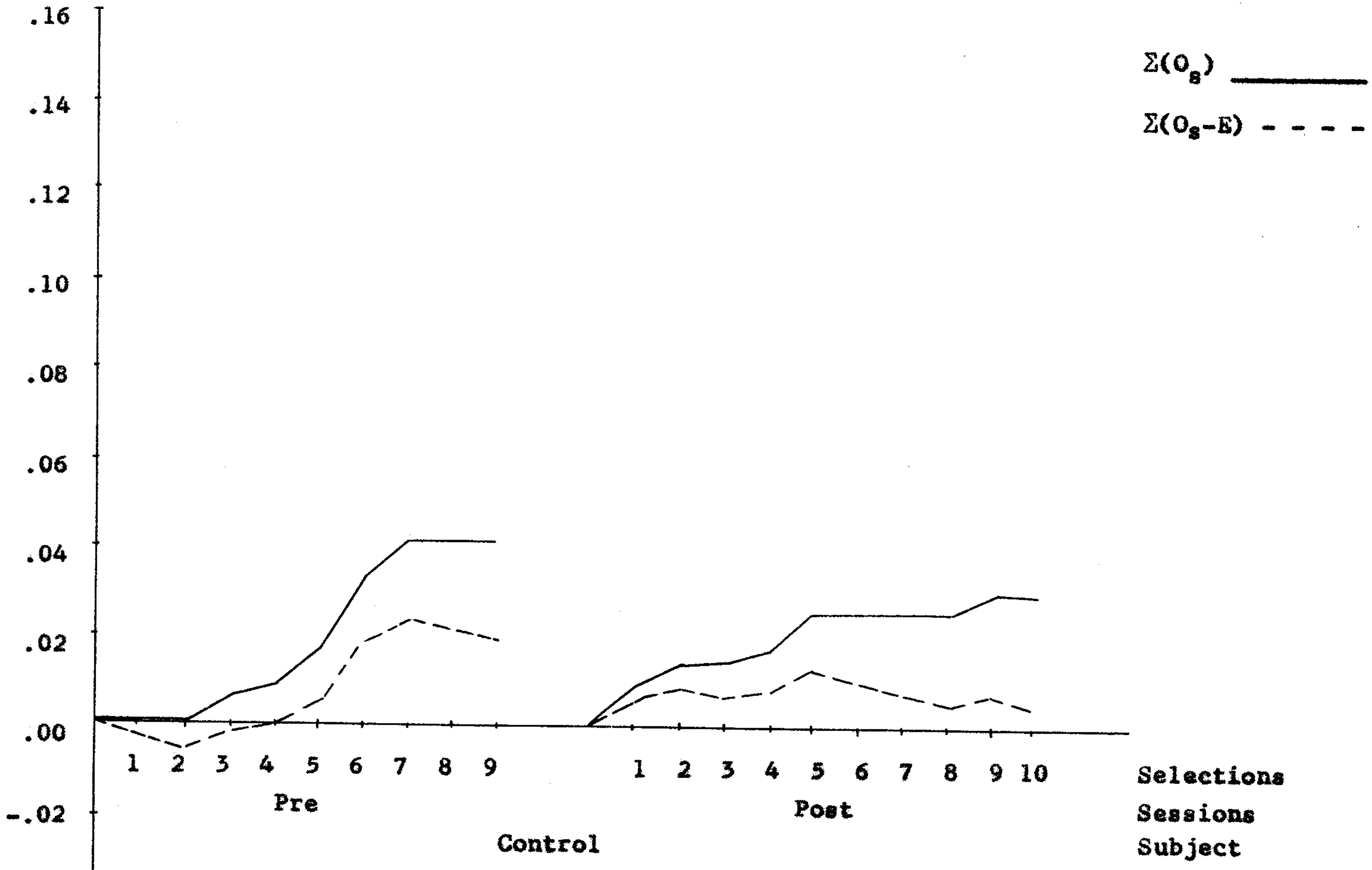

FIGURE 28

PERFORMANCE CURVES FOR A CONTROL SUBJECT (SCHEMATA NORMS)
FOR PROBLEM 19 PRE AND POST-TESTING SESSIONS

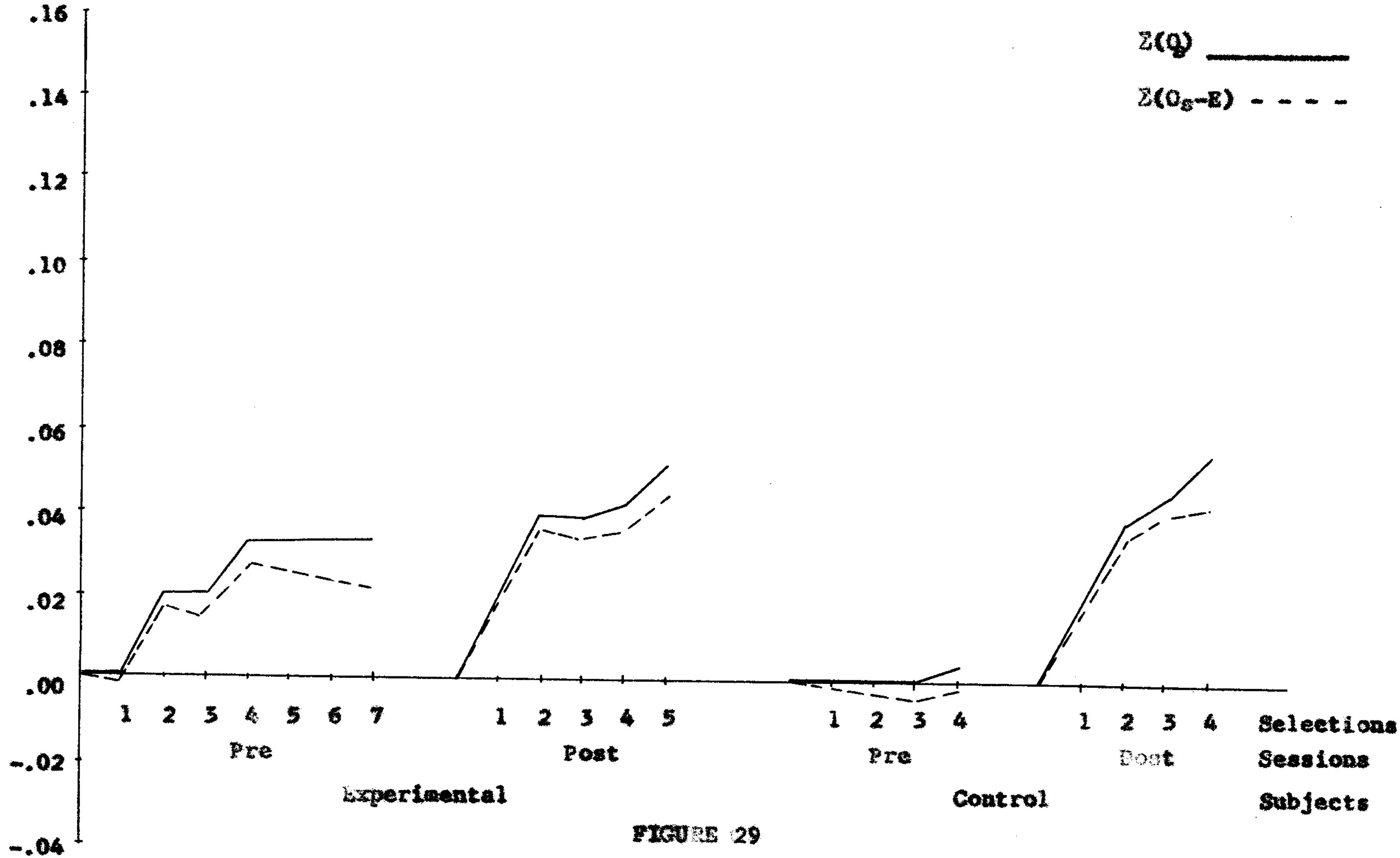

FIGURE 29

PERFORMANCE CURVES FOR A CONTROL-EXPERIMENTAL PAIR (SCHEMATA NORMS) FOR PROBLEM 25 PRE AND POST-TESTING SESSIONS

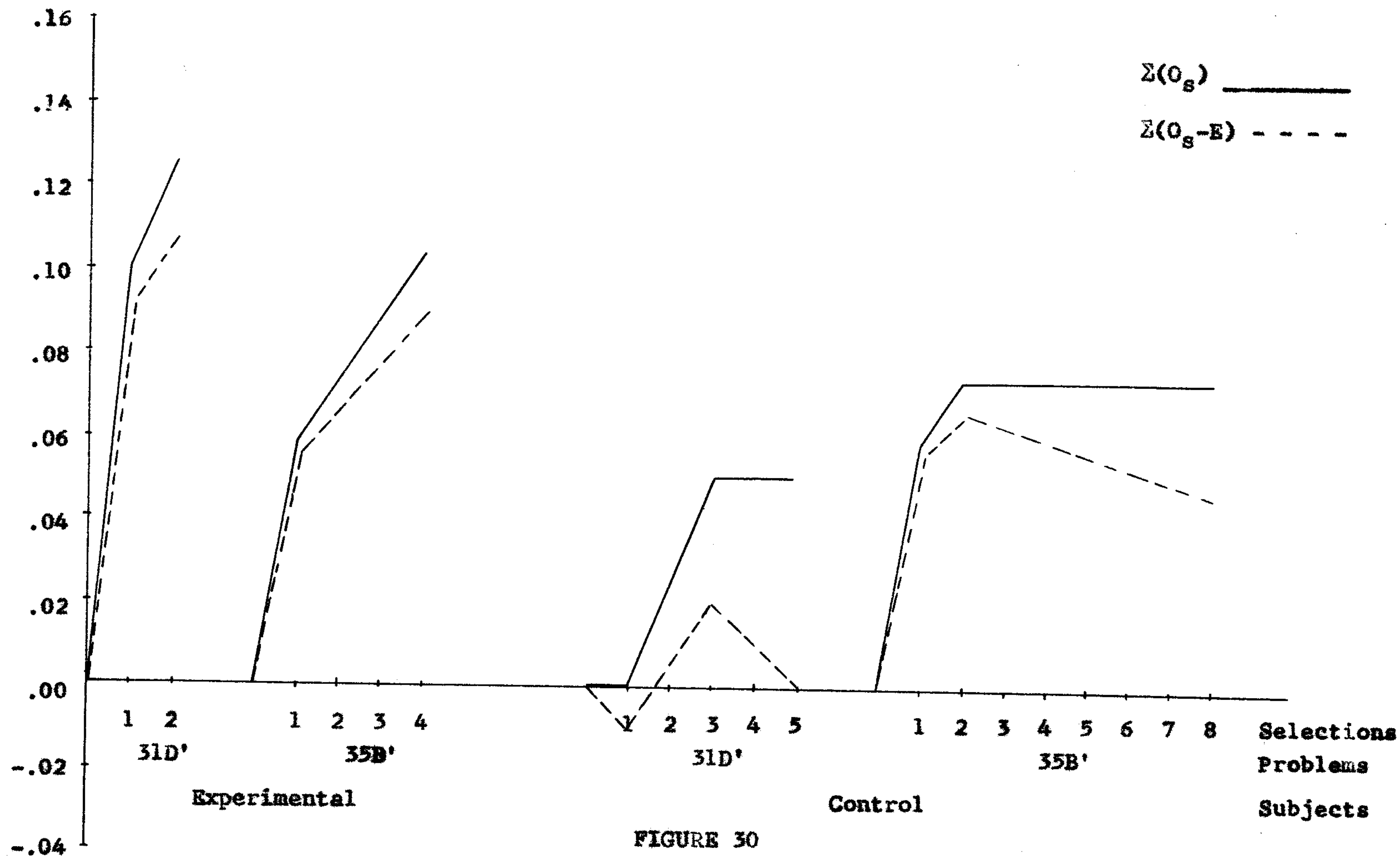

FIGURE 30

PERFORMANCE CURVES FOR A CONTROL-EXPERIMENTAL PAIR (SCHEMATA NORMS)
FOR PROBLEMS 31D' and 35B' POST-TESTING SESSIONS

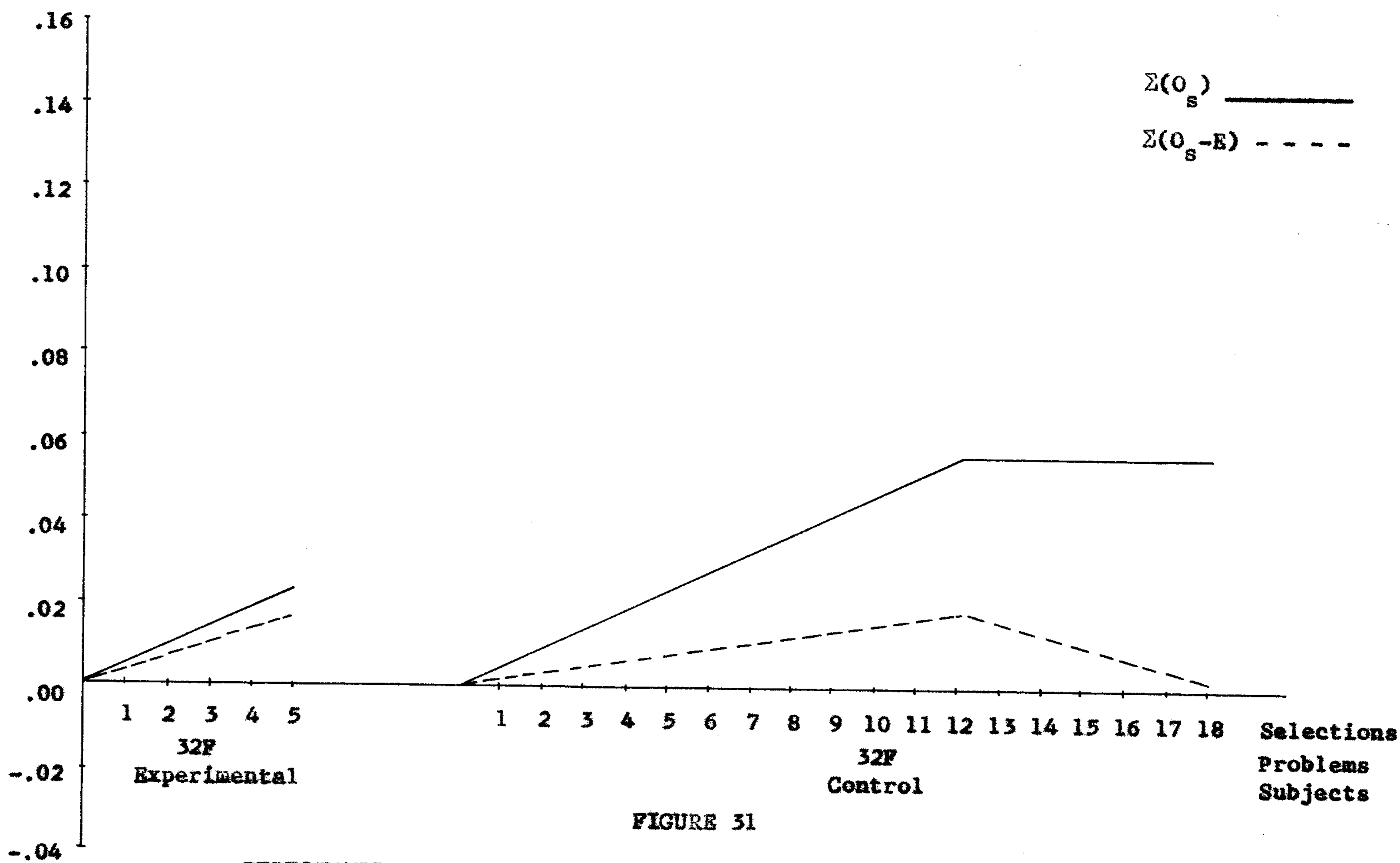

FIGURE 31

PERFORMANCE CURVES FOR A CONTROL-EXPERIMENTAL PAIR (SCHEMATA NORMS)
FOR PROBLEM 32F POST-TESTING SESSIONS

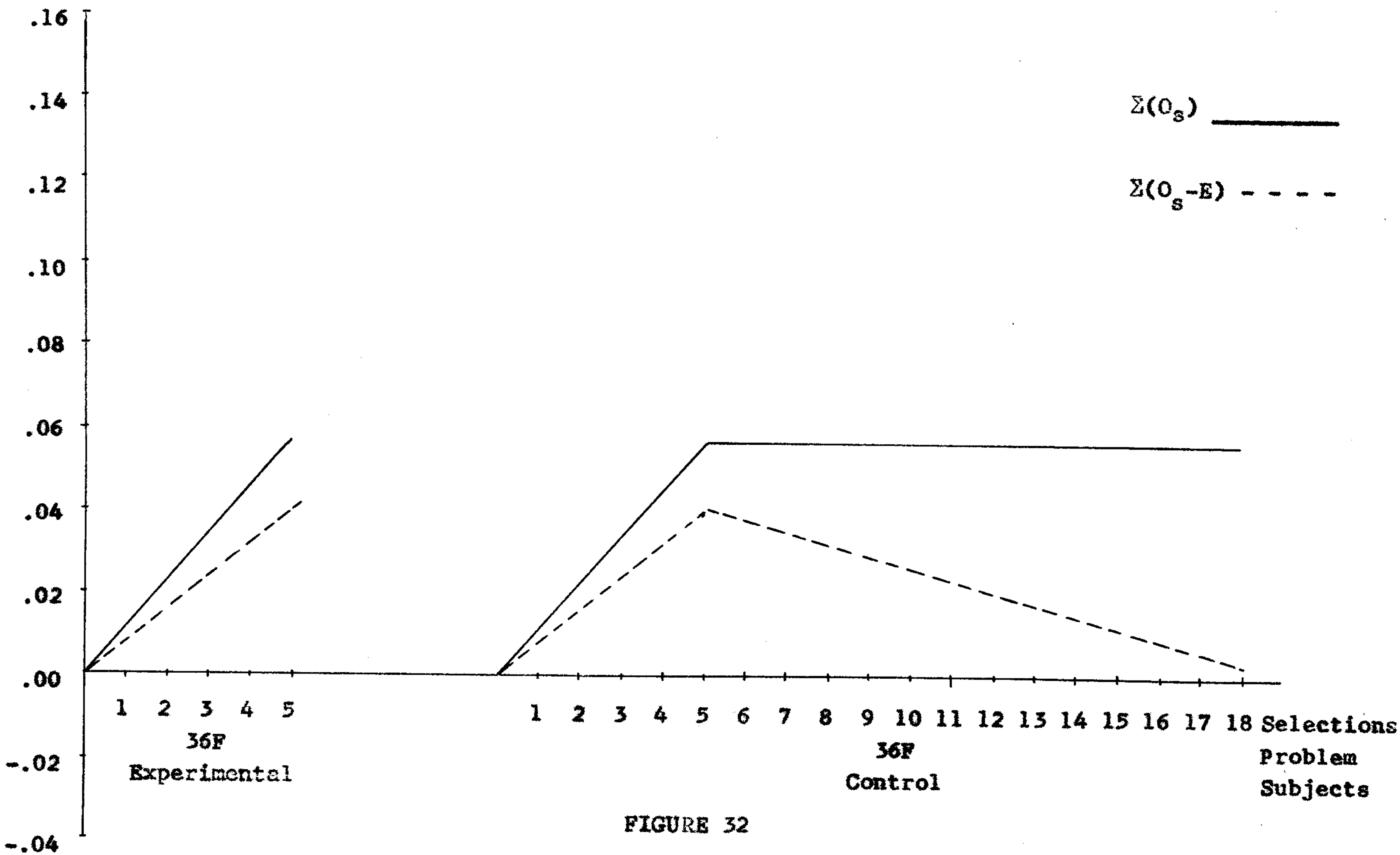

FIGURE 32

PERFORMANCE CURVES FOR A CONTROL-EXPERIMENTAL PAIR (SCHEMATA NORMS)
FOR PROBLEM 36F POST-TESTING SESSIONS

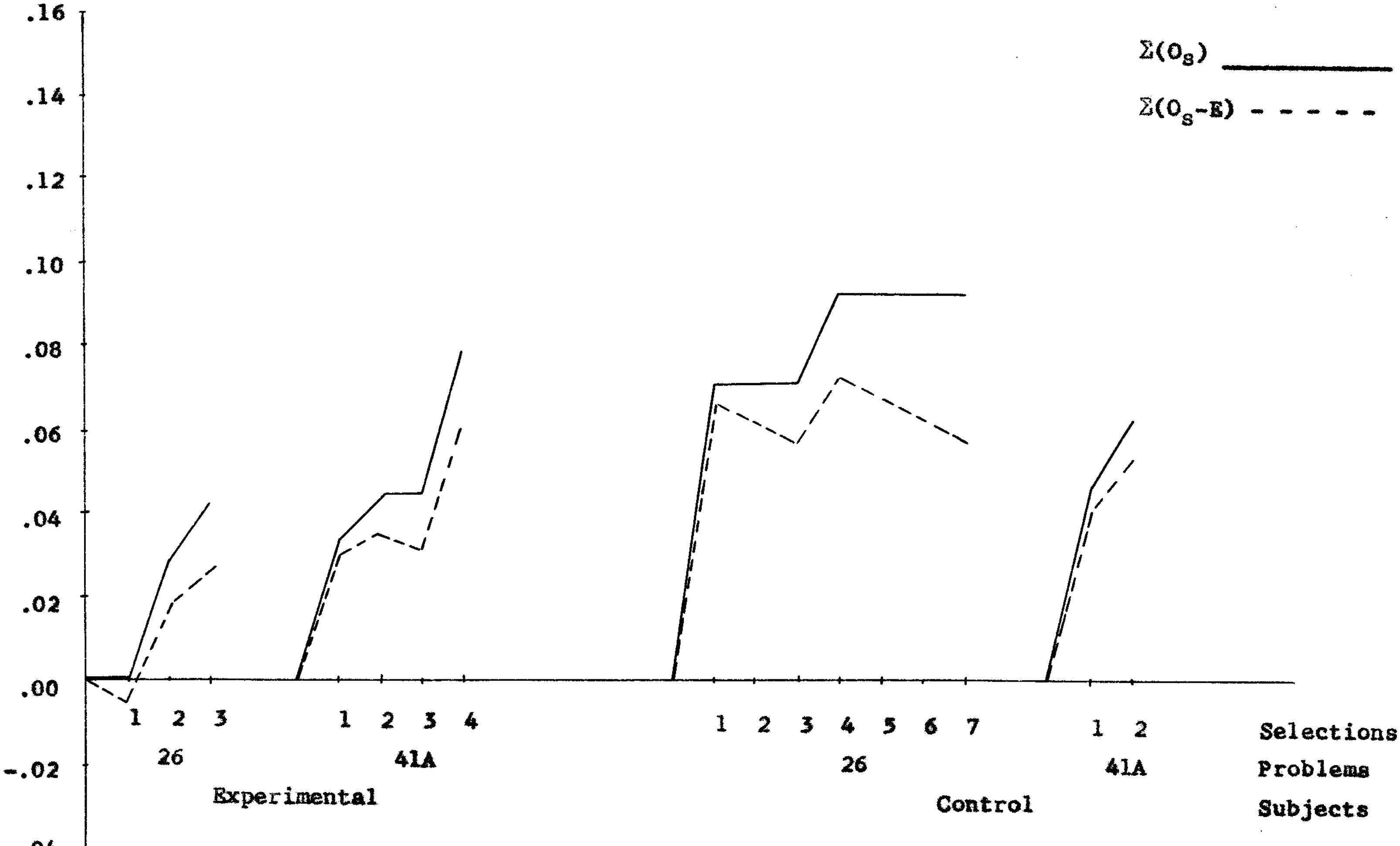

FIGURE 33

PERFORMANCE CURVES FOR A CONTROL-EXPERIMENTAL PAIR (SCHEMATA NORMS)
FOR PROBLEMS 26 and 41A POST-TESTING SESSIONS

d) Convex sets:

After scoring every control and experimental subject using schemata norms on the problems of the pre and post-testing sessions, poligonal convex sets were drawn by plotting the (0_s) score on the abscissa and the $(0_s\text{-}E)$ score on the ordinate, (see methodology #3).

Comparing the convex sets for control and experimental subjects (figures 34 to 45 inclusive) on problems 1, 19, and 25 in the pre-testing and post-testing sessions no clear differentiation is found. In problem 1 the convex set for the experimental high school students in the post-testing session shows a greater variation than for the control subjects in the $(0_s\text{-}E)$ score.

For problem 31D' the "logical sequences" to be followed in order to solve the problem are 2,4,7 or 2,7,4 and 2,3,8 or 2,8,3. The convex sets for problem 31D' (figure 46 and 47) and the sequences followed by the subjects whose tactics fall on the boundaries of the convex sets show that five of the experimental high school subjects followed the sequence 2,4, and 7 while just 1 control subject followed that sequence. For the college students eight of the experimental subjects followed the sequences 2,4,7 or 2,3, and 8 while 1 control subject followed the sequence 2,4, and 7. All of these subjects have a (0_s) score = .15 and a $(0_s\text{-}E)$ score = .12.

The sequences of the subjects that have a (0_s) score = .15 but a $(0_s\text{-}E)$ = .11 (experimental high school subjects 2 and 11, experimental college subjects 5,12,16 and 18 and control college subject 18) show that all of them selected cards corresponding to one of the sequences 2,4,7; 2,7,4 or 2,8,3; but, they selected one question more. This question was placed in the middle or at the end of the sequence and this question belongs to the other logical sequence. For example, experimental high school subject 11 selected the sequence 2,7,4,8 and experimental high school subject 2 selected the sequence 2,3,4, and 7.

The sequences of the subjects whose (O_s) score = .15 and (O_s-E) score = .10 (experimental high school subjects 3 and 14; control high school subject 19; experimental college subjects 10, 13, 15, 17 and 19) show that they have selected the two sequences one after the other. Experimental college subject 13 and experimental high school subject 3 selected 2, 4, 7, 3, and 8. The other subjects alternated between the two sequences.

In the high school students experimental subject 9 and control subjects 9 and 13 have a (O_s) score = .15 and a (O_s-E) score = .09. The sequences followed by these subjects show that they selected beside the two sequences one more question. This means that they have selected six questions in order to solve the problem instead of the three required ones.

The subjects with a (O_s) score = .15 and a (O_s-E) score = .08 (control college subject 15 selected 7 questions; the two required logical sequences and two more questions. Experimental high school subject 4 with a (O_s) score = .15 and a (O_s-E) score = .064 had selected the sequence 2,4,3,7,9,8,1,10 and 6. It can be seen that sequence 2,4, and 7 is located among the first 4 questions he had selected).

In figure 46 the convex sets for high school subjects show that experimental subject 12 and control subject 16 have the same (0_s) score = .125. Their sequences are 2,4 (subject 12) and 2,3,6,7,8,5,4,1,9,10, (subject 16). Notice that the first two questions belong to one of the logical sequences, and, that is the reason that they have the same (0_s) score. But, while subject 12 asked no more questions and his (0_s-E) score =.10, subject 16 asked 8 more questions. He is punished for all these useless questions he has asked and his (0_s-E) score = .025.

Looking at the same figure 46 control high school subject 6 has a (0_s) score = .05 and a (0_s-E) score = .02. His sequence is 8,4,7; he selected three questions but he did not ask questions number 2 which is the most important and should, according to the schemata norms, be always asked in the first place. Experimental high school subject 7 and 18 selected the sequences 6,8,2,4,3 and 3,2,4,8,7 respectively. The only question that has a score is question number 8 for subject 7 and question number 4 for subject 18. They had selected the other required questions of the logical sequences, but in a wrong order and consequently they received a score of zero for them. The sequences of subjects 7 and 11 of the control group are 7,2,8,4,3,1 and 4,7,2,3,8,5 respectively. Their situation is similar to experimental subjects 7 and 18 so they received a score for only one question (8 and 7 respectively). The (0_s) score for the 4 subjects is .025. Nevertheless they differ in terms of the (0_s-E) score by the fact that experimental subjects 7 and 18 selected 4 questions with scores of zero, and their (0_s-E) score = -.025 while control subjects 7 and 11 have 5 questions with scores of zero and their (0_s-E) score = -.035.

Control subjects 4,5 and 18 have a (0_s) score =.00. This means that they have not selected any required question in the right order. Subject 4 selected four questions and his $(0_s\text{-}E)$score = -.04 while subjects 5 and 18 selected 5 questions and consequently their $(0_s\text{-}E)$ score = -.045.

A similar approach can be followed in order to complete the study of the convex set for the college students (figure 47).Control college subject 12 has a (0_s) score = .10 and a $(0_s\text{-}E)$score = .065.The sequence that he followed is 2,5,6,7,4,3,9,8,10. He received a score for question number 2 and a zero score for all the other questions.He selected question 7 and 4 but in the fourth and fifth order instead of the second and third order.

Control subjects 2,5, and 13 have the same (0_s) score = .05.This means that they received a score for the second and third questions they asked. The differences in the $(0_s\text{-}E)$ scores are due to the fact that subject 13 selected 8 questions for which he received a score of zero while subjects 2 and 5 selected only one question with a zero value.Looking at the bottom of the convex set there are 5 control subjects and 1 experimental subject that have an (0_s) score =.025.They received a score for just one question.. The differences in $(0_s\text{-}E)$ scores are due to the number of questions that they have selected with a score of zero.

In summary, it can be concluded that the convex sets for problem 31D' shows a clear differentiation between control and experimental subjects. Seventeen experimental college subjects are located in the upper boundaries of the convex set while only three control college subjects are in that place. For the high school students the ratio is eleven experimental to four control subjects.

The convex set for problem 35B' (figures 48 and 49) show that 9 of the college students followed a logical sequence while 1 of the control subjects followed a logical sequence. For the high school students 7 experimental subjects had followed one of the logical sequences while just 1 control subject did so. If one wished to do a detailed study for problem 35B', a similar approach as the one followed for problem 31D' should be performed.

Figures 50 and 51 present the convex sets for problem 32F. In figures 52 and 53 the convex sets for problem 36F are presented for the high school and college students respectively.

Notice that in these problems (type b) the sequences followed by the subjects are not presented, but the number of questions that the subject used in order to solve the problem is presented. Inspection of the figures 50 and 51 show that the convex sets for the control subjects in both high school and college students coincide on the lower boundary with the convex sets for the experimental subjects, nevertheless, the convex sets for the experimental subjects show higher values on the left upper corner.

In figures 52 and 53 the convex sets for the control subjects become a line that is located in the lower boundary of the convex set for the experimental subjects. It can be seen that only the experimental subjects asked the required or less than the required number of questions. Every control subject asked more than the required number of questions in order to solve the problem. For the high school control subjects the number of questions ranked from 6 (subjects 3 and 7) to 18 questions (subjects 5,9,11,12,13,17), that is, the maximum number of questions they can ask. For the college control students the rank goes from 9 questions (subjects 2,3,14) to 18 questions (subjects 4,8,10,15,17,19). In the experimental high school students 4 of them solved the problem with the required 5 questions, 4 subjects solved it with 4 questions and 1 subject solved it with 3 questions. In the college students 8 of them used the required number of questions in order to solve the problem. 2 subjects solved it with 4 questions and 2 other subjects solved it with 2 questions.

It can be seen that several experimental subjects solved the problem with less than the required number of questions. The problem can be solved with 4 questions if the subject assumes that the code is based on the color and kind of lines, and he starts asking questions on this basis. To follow this approach is a very "good guess" for this problem and it was followed by several experimental subjects who had similar problems in the training sessions, but, computing the schemata norms on 4 questions will punish the control subjects who do not know the problem at all and had no "good guessing" approach. It was decided that with 5 questions the problem could be solved even if the subject had no idea of the rationale underlying the assignment of values to the different areas. The convex sets for problem 36F show a clear differentiation between control and experimental subjects.

The convex sets for problem 26 in the high school students (figure 54) show higher values for the experimental than for the control subjects . In the convex set for college students (figure 55) the experimental subjects show lower score than the control subjects.

The convex set for problem 41A in the high school students (figure 56) shows a greater variation, in terms of the (O_s) score, for the experimental subjects than for the control subjects; the reverse is observed on the (O_s-E) score. In the convex set for the college students (figure 57) the higher values are observed for the experimental subjects..

A detailed study of the convex sets was presented here for problems 31D' and 36F. These two problems have been selected because their schemata is very clear and a small number of questions are required in order to solve the problems. There is no other reason and a similar study can be performed with any one of the convex sets for any problem.

In summary, the study of the convex sets permit one to differentiate between the control and experimental subjects. It is possible to see the sequence or tactic followed by each subject in order to solve the problem. When the convex sets are based on the schemata norms as in the cases described here, it is possible to see the subject that has followed a "logical" sequence, he will be at the upper corner of the convex set. It is also possible to see how a subject departed from the "logical" sequences. It seems that when the subject starts asking the questions in a "logical" manner but does not finish the sequence, which means that he has asked less than the required number of questions, his tactic will be located on the upper horizontal boundaries of the convex set. The fewer the questions he asked the lower will be his position on that boundary. The subject who falls on the lower corner of the convex sets will be the subject who has asked none or very few of the questions that belongs to any "logical" sequence. His location on that boundary will depend on the number of useless questions he has asked. The subject who starts asking question in a "logical" sequence but then departs from that sequence and asked questions at random will be located on the lower horizontal boundaries of the convex sets. Again, his position on that boundary will depend on the number of questions he has asked in a "logical" way. The subjects who asked all the questions that belong to one of the "logical" sequences according to schemata norms, will be located on the upper vertical boundary of the convex set. If he asked just the required questions, he will fall in the upper corner of the boundary. But, if beside the required questions he has asked others, his location will fall lower on that upper vertical boundary according to the number of useless questions asked.

The subjects whose tactics are located inside the convex sets are the ones who asked as many questions of a "logical" sequence as the subjects who are located on the same ordinate on the boundaries. Their position along that ordinate will depend on the number of useless questions asked.

All these implications can be seen by a close inspection of figures 46,47,48,49,52,53,56 and 57 that presents the convex sets for problems 31D', 35B', 36F and 41A which are the problems with a clear schemata.

There are cases where the problem can be solved using different sequences or tactics, but not all of them have the same weights. In other words, if there are several "logical" tactics, there is one that is "more logical" than the others or there is a group of questions that should be asked. There is no absolute position in the sequence for every question. The results are that several of the "logical" sequences will have different scores and the subjects who followed them will be located at different points on the convex sets. This is the case of experimental college subjects 3,12 and 17 and control college subjects 4 and 1 on problem 26 (figure 55) who have followed one of the "logical" sequences, nevertheless, their locations are different on the convex sets.

Looking at the convex set for the same problem (26) in high school students (figure 54), it can be seen that experimental subject 11 had followed a "logical" sequence. However, his score is lower than subject 19 who had selected a "logical sequence" but with two more questions at the end. This happened because according to the schemata norms subject 19 had selected a sequence with more weights than the sequence selected by subject 11.

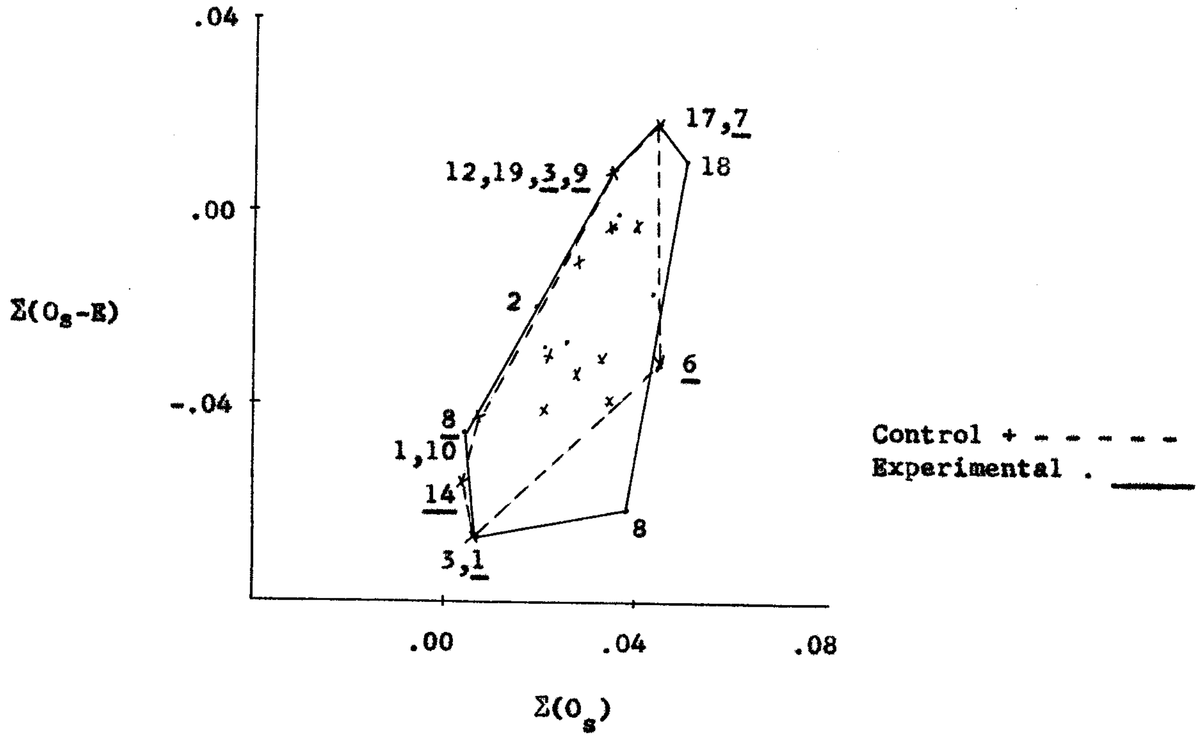

FIGURE 34

LIMITS OF PERFORMANCE OF HIGH SCHOOL CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 1 OF THE PRE-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
7	4,7
3,9	4,8
8	1,2,4,5
14	1,2,5,9,4
1	1,2,3,5,6,7
6	3,4,8,7,9,6

Experimental

Subjects	Tactics
17	3,7
12	4,5
19	4,8
2	1,5,3
1	2,1,8,3
10	1,2,8,4
3	2,1,3,7,4,8
8	5,7,1,4,3,2,7,8
18	4,7,8

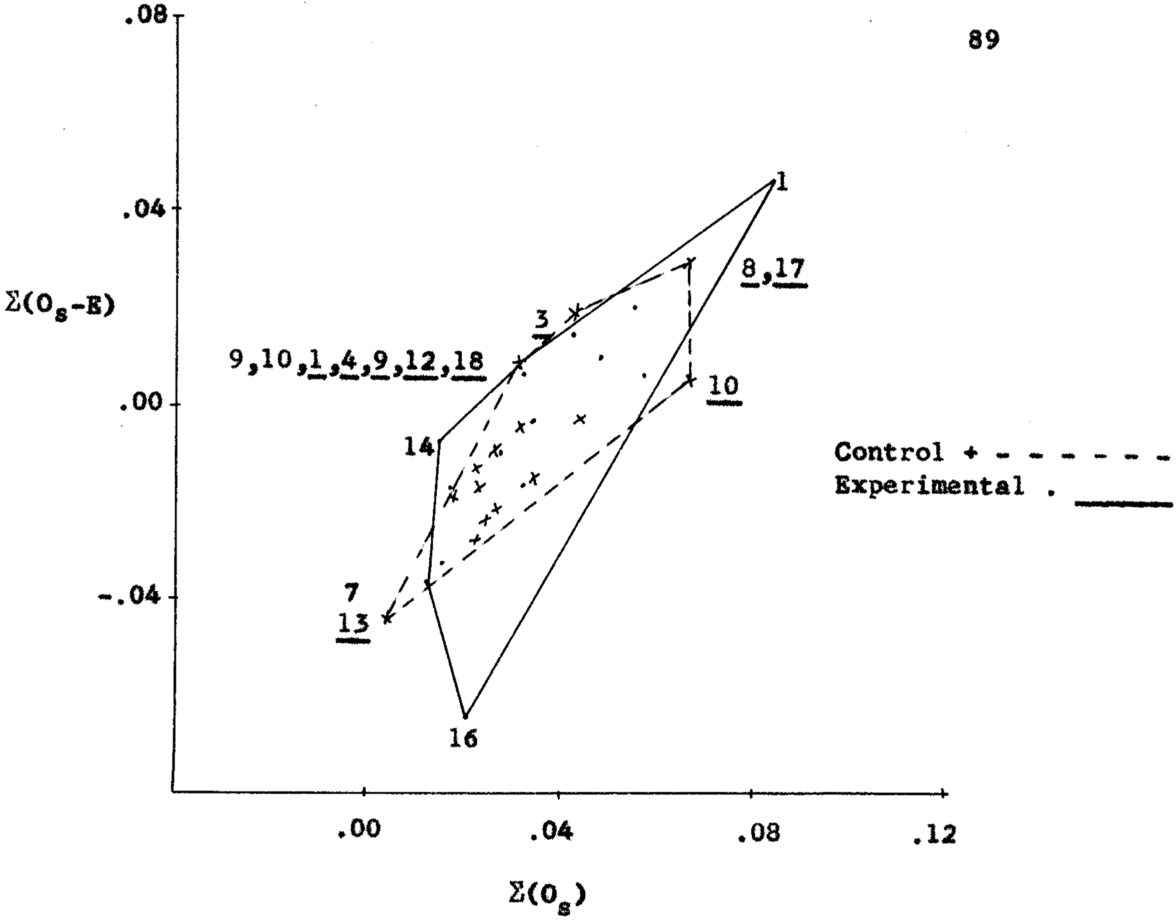

FIGURE 35

LIMITS OF PERFORMANCE OF COLLEGE CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 1 OF THE PRE-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
8	4,5,7
17	4,8,7
3	4,7
1,18	3,8
4,12	4,8
9	4,5
13	1,2,8,4
10	4,5,7,6,3

Experimental

Subjects	Tactics
1	4,6,7
9	4,8
10	4,5
14	5,2
7	2,9,3,1
16	1,3,5,7,9,2,4

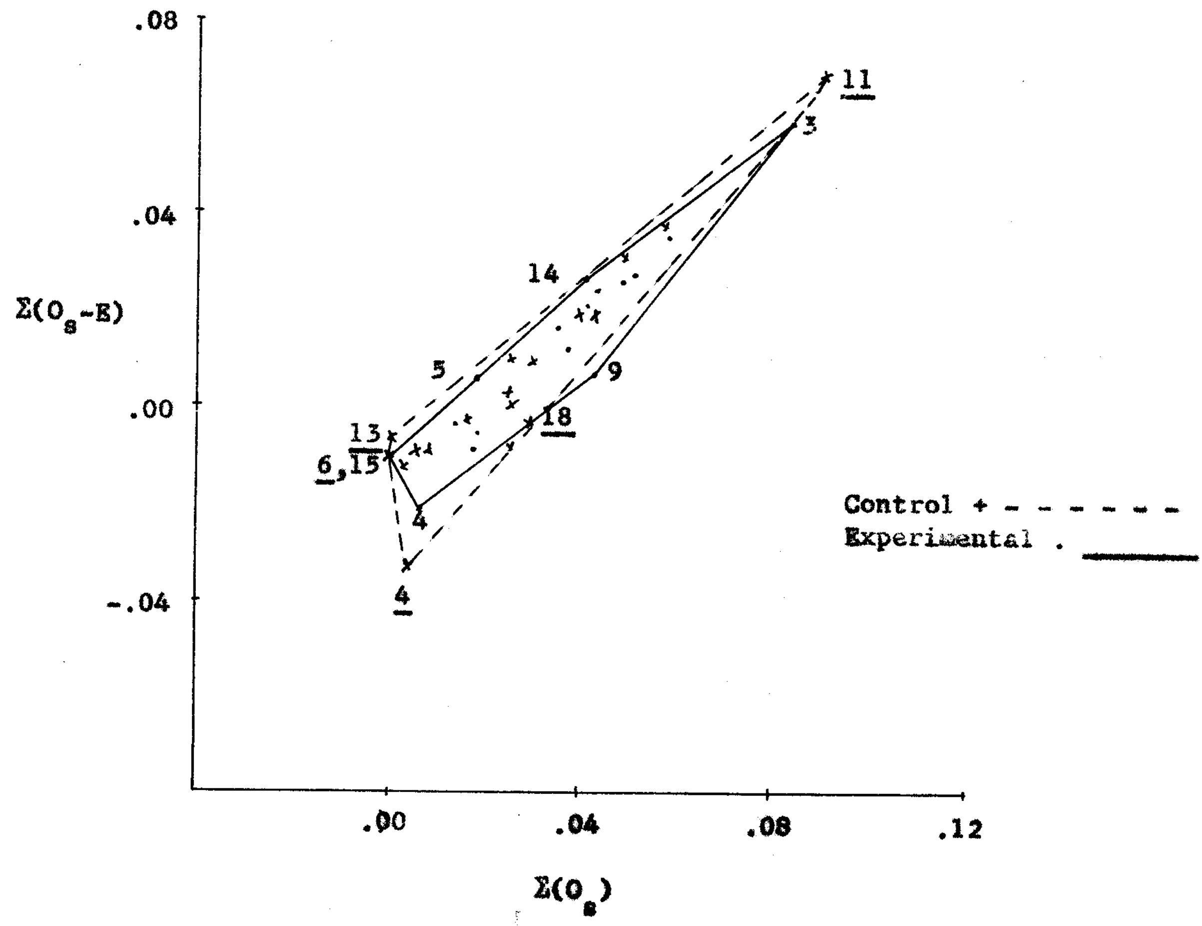

FIGURE 36

LIMITS OF PERFORMANCE OF HIGH SCHOOL CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 19 OF THE PRE-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control Subjects	Control Tactics	Experimental Subjects	Experimental Tactics
11	6,15,16,17,2,18,4,19,5	3	6,16,17,15,2,18,4,19, 5,20,8,12
13	5,12,13	14	5,8,2,6,4,18
6	5,12,14,13	5	9,15,2,18,4
4	5,9,12,13,14,2,19,18, 20,6,17,16,15,7,4	15	5,14,13,12
		4	5,12,6,17,15,13,9,19, 20,18,4
18	9,12,13,14,7,16,19,2, 4,5,15,18,20,17	9	2,18,4,19,5,20,6,15,8, 12,14,9,11,1

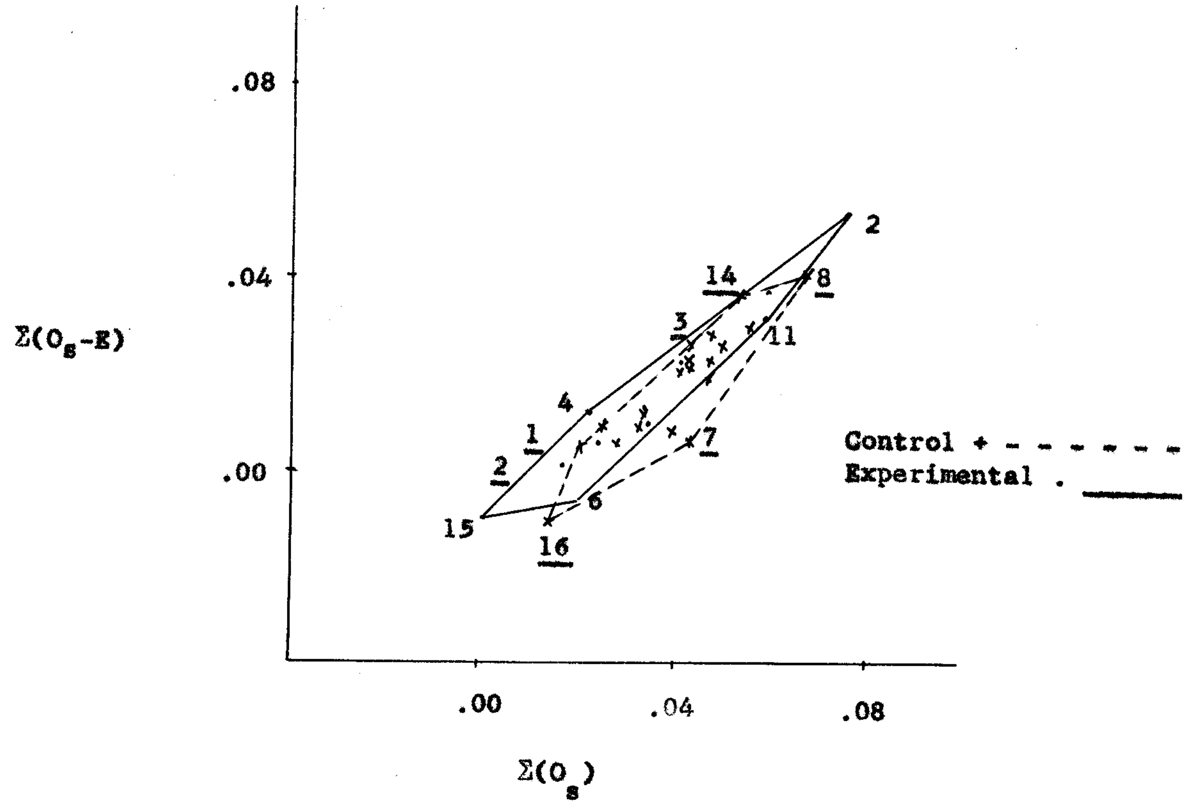

FIGURE 37

LIMITS OF PERFORMANCE OF COLLEGE CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 19 OF THE PRE-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
8	6,15,17,2,19,5
14	2,6,15,16,5,19,17
3	6,16,19,5,2,17
1	2,19,5,18,4,17
2	5,2,20,19,18,14
16	5,8,9,15,17,6,16,2,18,19
7	9,12,13,14,2,18,19,20,4,1,5,6,15,17

Experimental

Subjects	Tactics
2	19,2,16,6,17,18,4,15,5
4	6,2,19,5
15	5,14,13,12
6	2,6,7,19,5,9,12,20
11	2,20,18,4,5,19,15,17,16,6

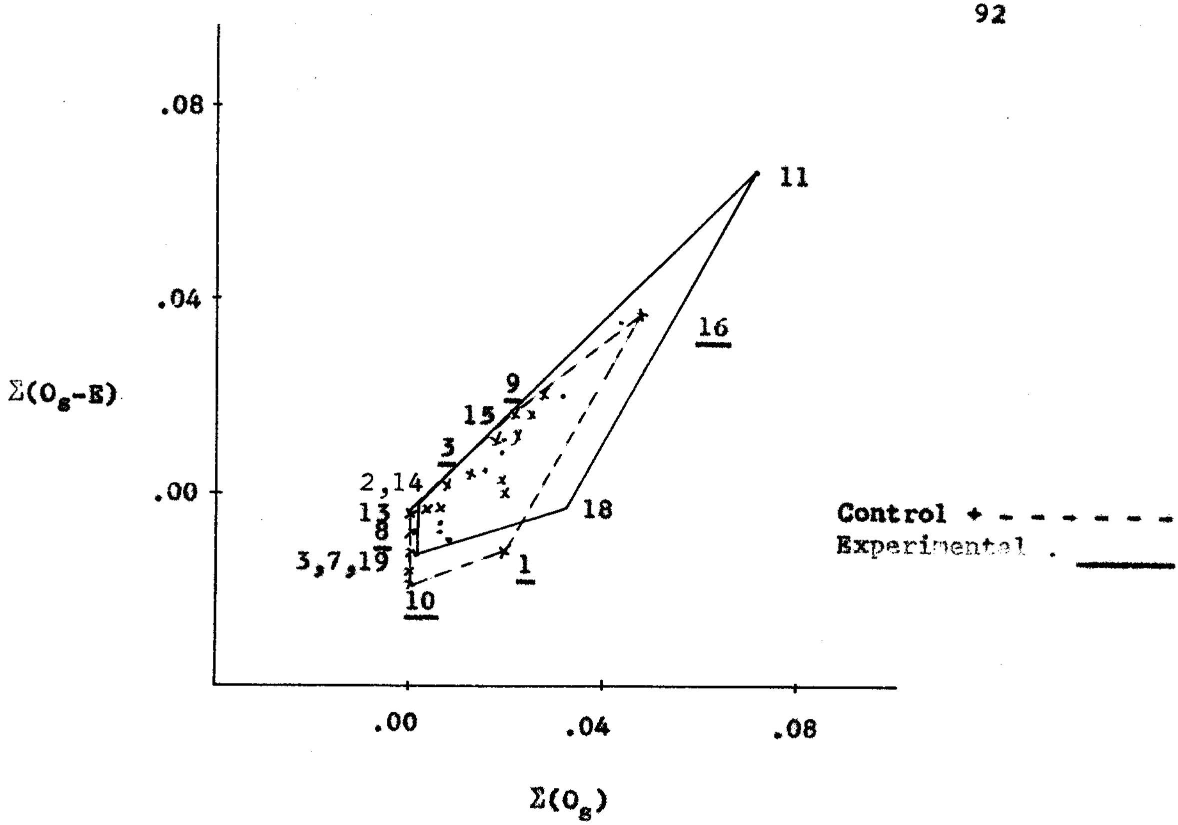

FIGURE 38

LIMITS OF PERFORMANCE OF HIGH SCHOOL CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 25 OF THE PRE-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
16	9,2,11,12,15,18
9	1,2,3,10,20
3	9,19,7,15
8	1,9,24,16
10	1,3,2,4,8,9,12,14,15,16,17,18,24
1	1,2,3,4,5,6,7,8,9,10,12,13,14,15,16,17,18,19,25,24

Experimental

Subjects	Tactics
11	10,2,23,24,20
15	8,7,3,9,24,20
2	2,7,9,20
14	25,23,11,15
13	2,4,12,22,11,25
3	23,24,25,9,14,15,16,18,26
7	1,9,4,6,12,17,23,24,18
19	12,9,1,2,4,24,15
18	2,3,10,20

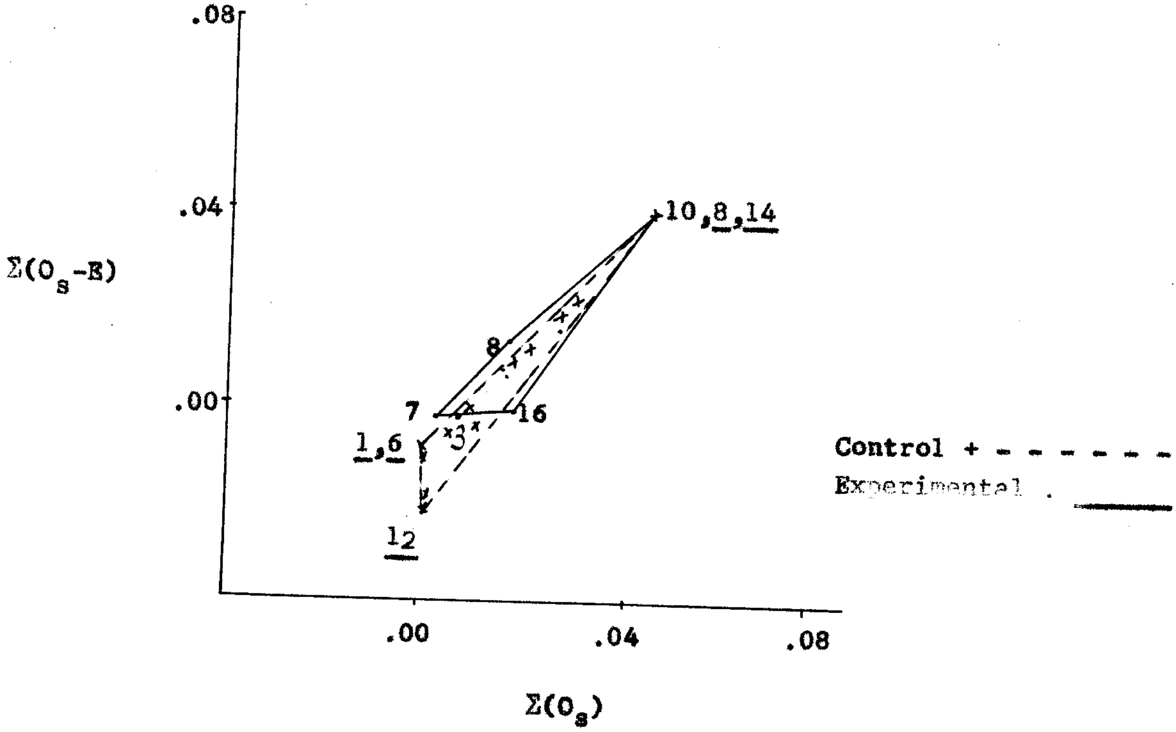

FIGURE 39

LIMITS OF PERFORMANCE OF COLLEGE CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 25 OF THE PRE-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
8	10,23,2,24,20
14	1,2,9,24,20
1	2,3,1,9,5
6	1,9,15,11,18
12	2,3,1,4,9,6,11,13,14,16,15,20,22,21

Experimental

Subjects	Tactics
10	9,2,23,15,5
8	10,25,20
7	1,10,8,20
3	2,1,3,4,9,15
16	1,2,3,4,5,9,14,17,24,25,15,20

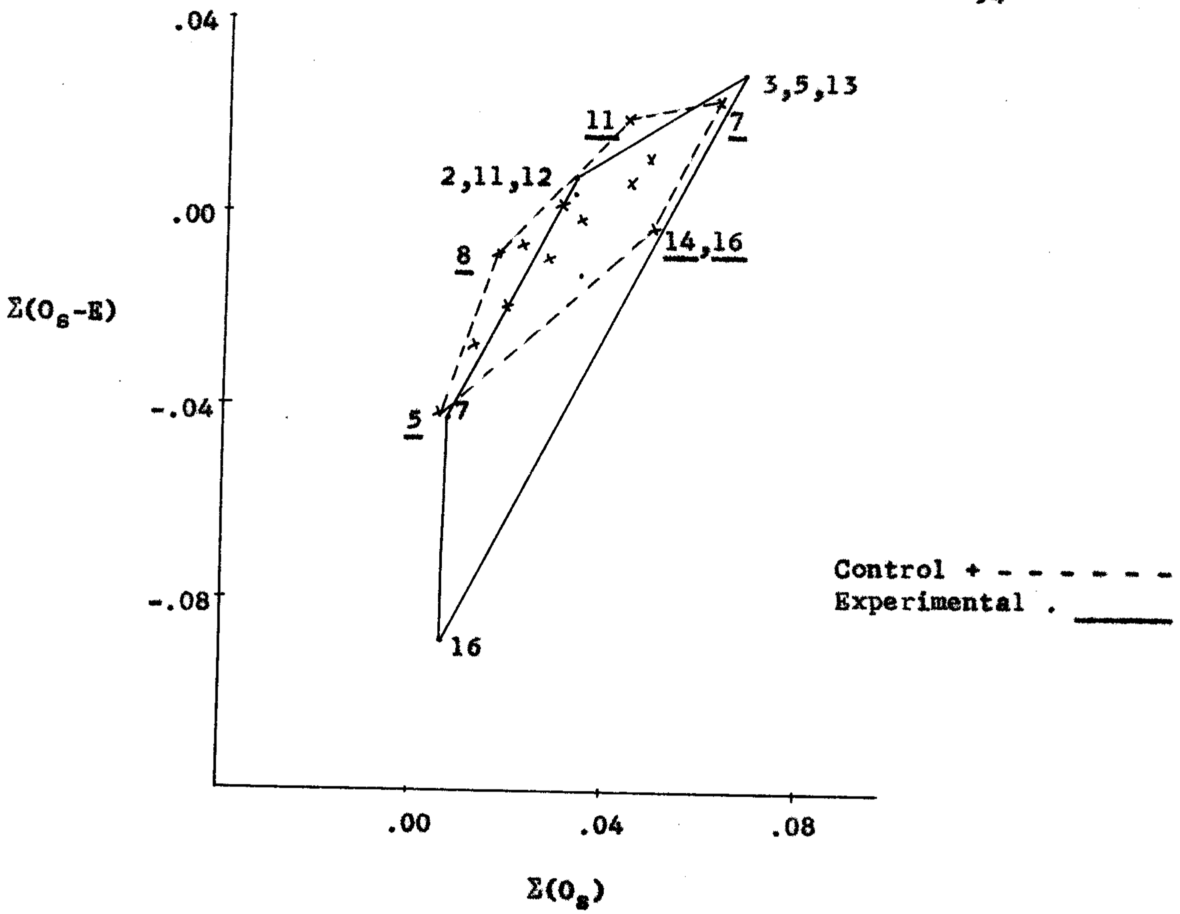

FIGURE 40

LIMITS OF PERFORMANCE OF HIGH SCHOOL CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 1 OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control		Experimental	
Subjects	Tactics	Subjects	Tactics
7	3,9,7	3,5	4,8,7
11	4,7	13	3,8,7
8	2,3	2,12	4,8
5	2,1,9,4	11	4,7
14	3,7,8,2	7	1,2,3,5
16	9,6,8,4	16	1,2,3,4,5,9,8,7

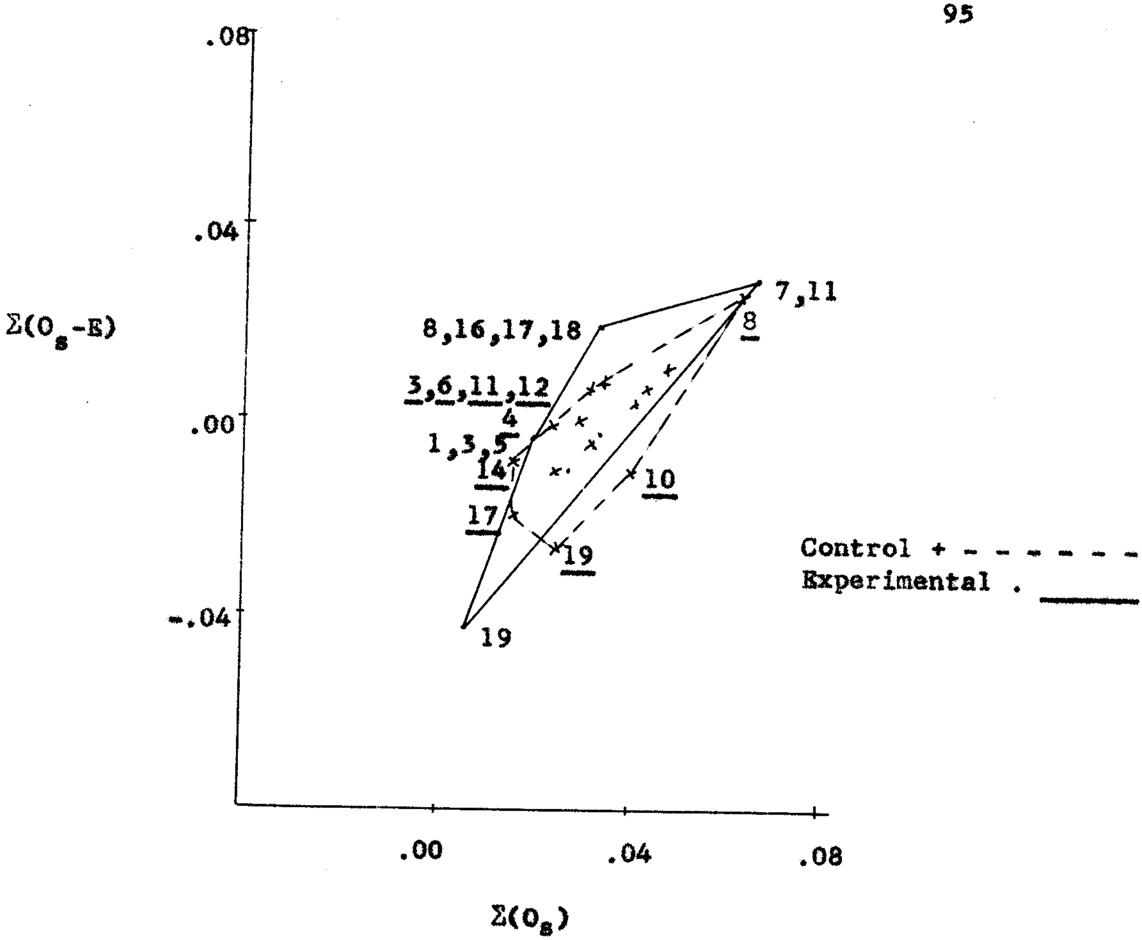

FIGURE 41

LIMITS OF PERFORMANCE OF COLLEGE CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 1 OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
8	8,3,7
3,6	4,5
11	3,8
12	4,8
14	6,9
17	2,5,8
19	5,1,4,6
10	4,5,8,7

Experimental

Subjects	Tactics
7	4,5,7
11	4,8,7
8,16,17,18	4,8
1,3,5	6,8
19	2,1,4,9

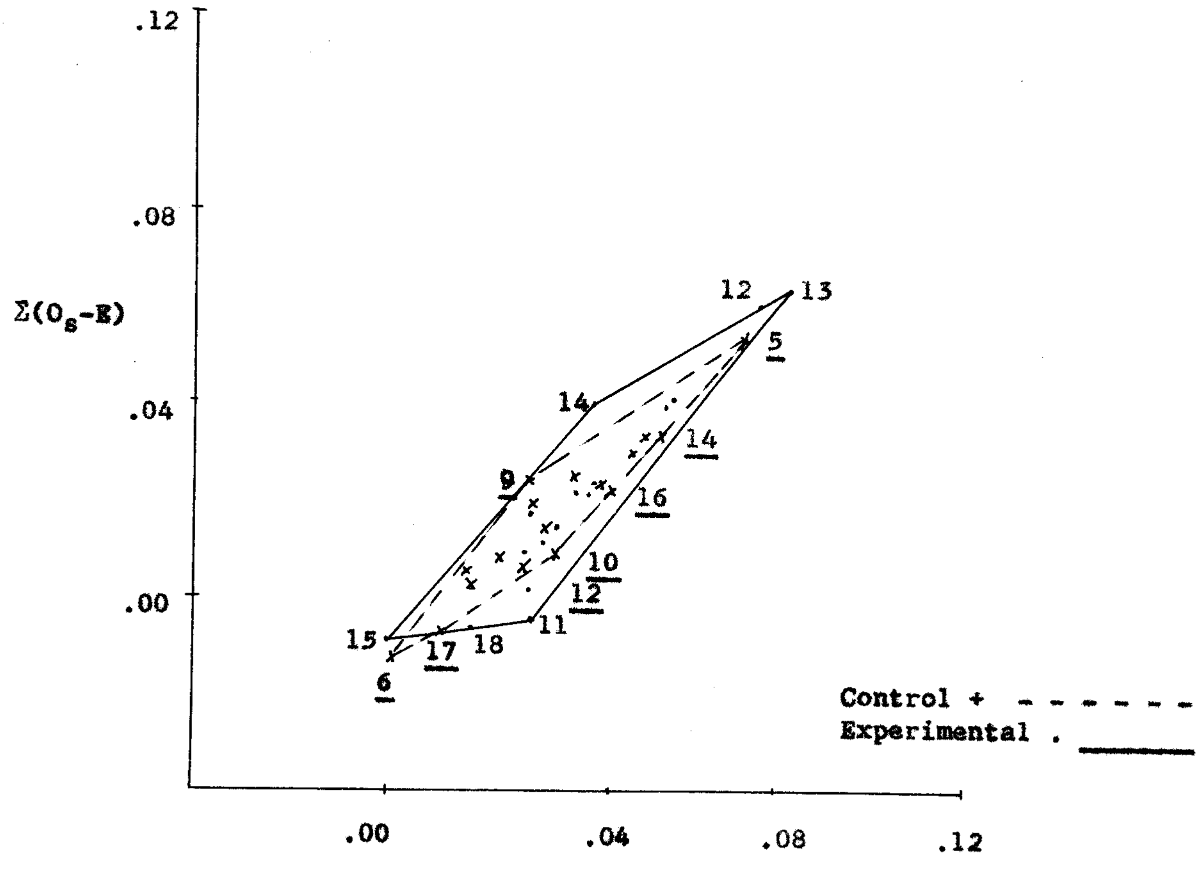

FIGURE 42

LIMITS OF PERFORMANCE OF HIGH SCHOOL CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 19 OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
5	6,16,15,17,2,18,19,20
9	2,18,19,20,5,4
6	5,9,12,14,13
17	2,6,5,9,13,14,17,16
12	2,18,4,19,5,20,12,6,15, 17
10	9,18,20,19,5,2,4,6,15,17
16	2,18,4,19,20,5,6,15,17, 16
14	2,20,19,18,4,5,6,8,15

Experimental

Subjects	Tactics
13	6,15,16,17,18,4,2,19,5
12	6,15,16,17,2,19,5
14	2,18,4,6,15,17,16,19,5
15	12,13,14,5
18	18,2,4,19,20,17,6,16,15, 5
11	2,18,19,20,4,8,12,13,14, 7,15,16,17,9

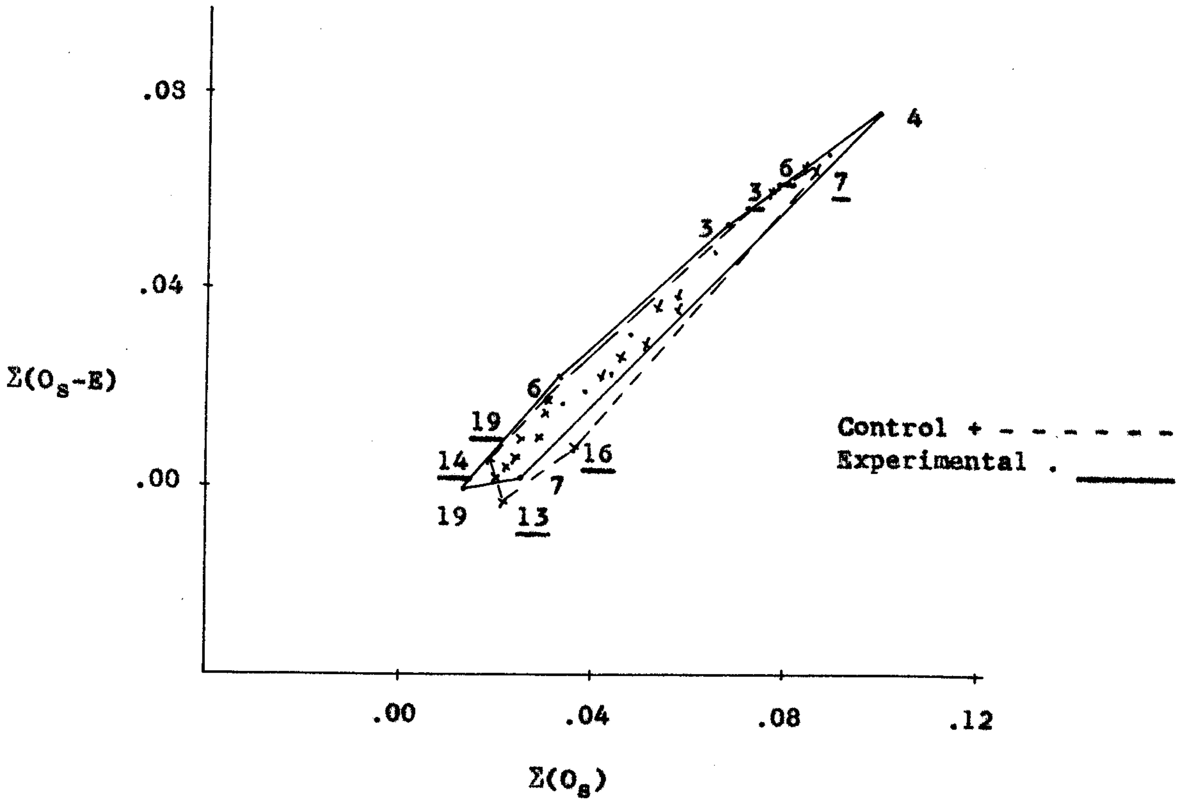

FIGURE 43

LIMITS OF PERFORMANCE OF COLLEGE CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 19 OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
7	6,15,16,17,2,18,19,5
6	6,15,16,2,18,19,5
3	6,16,15,17,2,19,5
19	2,20,18,19,5,17
14	2,19,7,15,17
13	2,18,4,19,20,6,7,16,17,5
16	2,20,6,15,8,1,18,4,19,5,17

Experimental

Subjects	Tactics
4	6,15,16,17,2,18,19,4,5
3	6,15,17,2,19,5
6	6,2,17,19,5
19	20,19,18,5,6,2
7	5,6,15,16,17,4,9,12,13

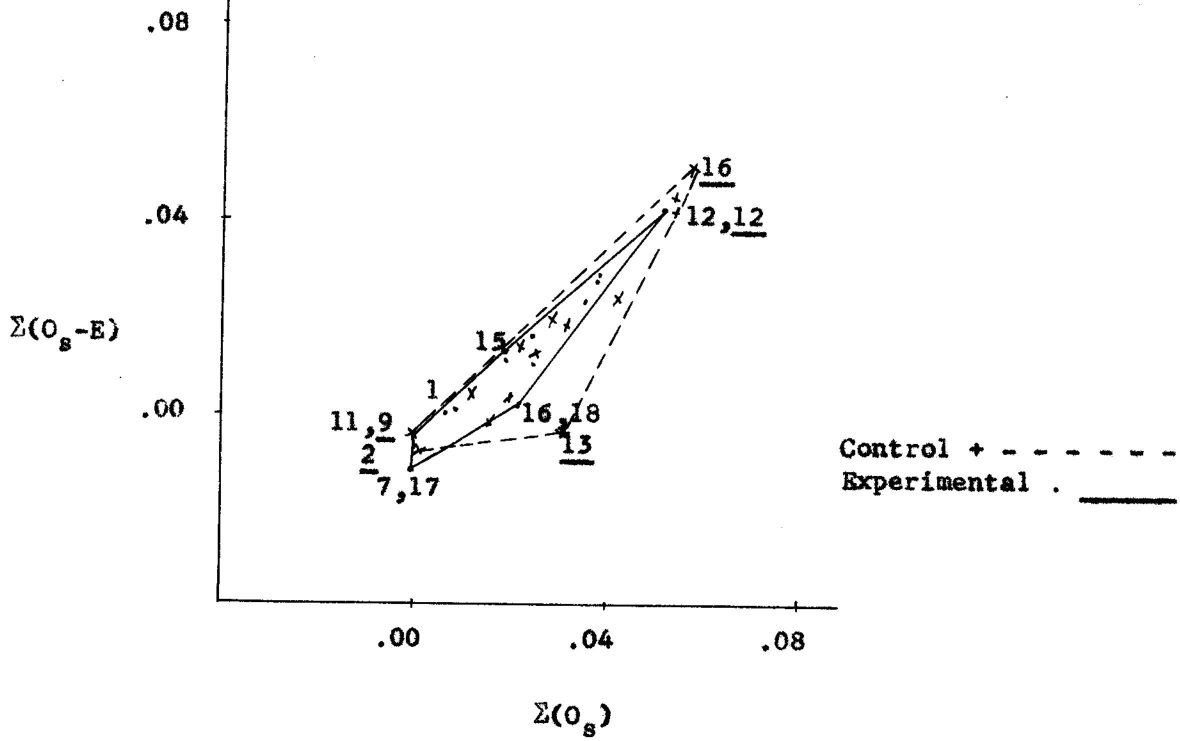

FIGURE 44

LIMITS OF PERFORMANCE OF HIGH SCHOOL CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 25 OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
16	10,2,23,15,20
9	2,9,1,20
2	7,9,8,26,17,18
13	2,23,15,20
12	10,8,23,20

Experimental

Subjects	Tactics
12	9,2,1,15,20
15	1,2,10,26
1	26,25,23,17
11	2,9,11,20
7	2,4,10,7,17,16,21,24
17	5,6,7,8,11,20,14,17,23
16	1,2,3,5,6,9,10,24,23,17,4,26
18	1,8,6,9,3,18,17,24,23,21,22,16

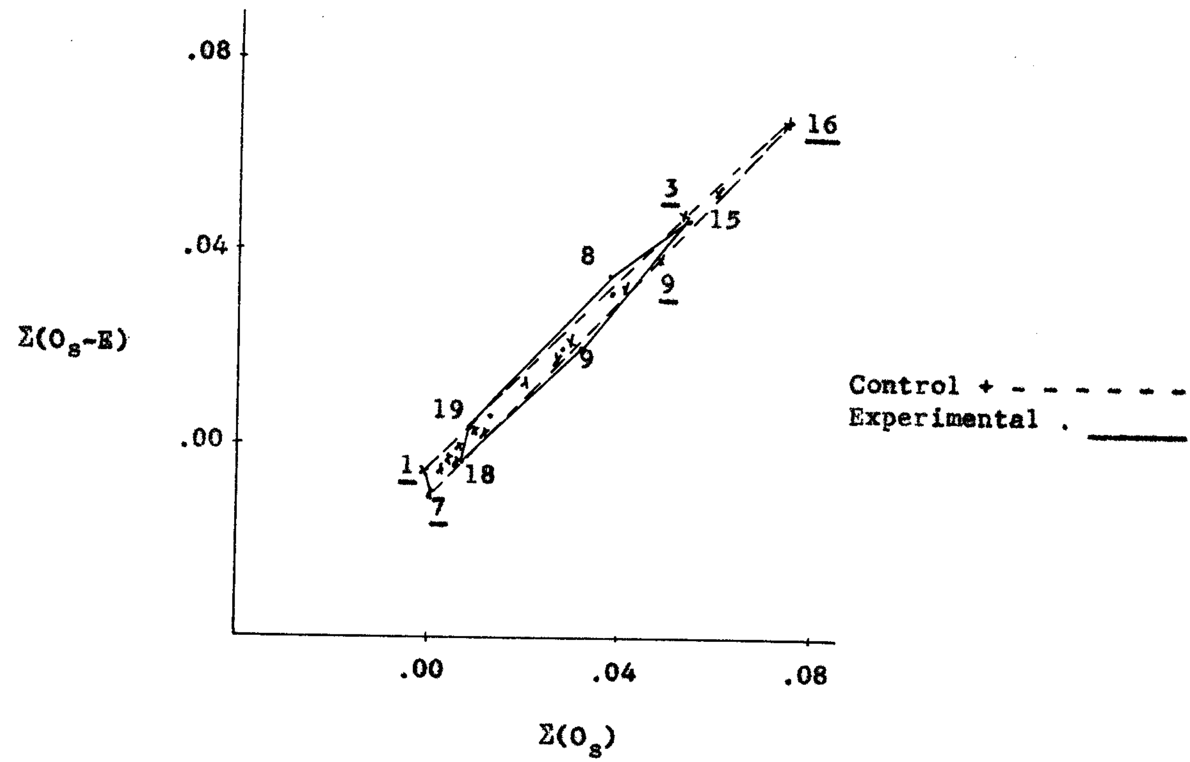

FIGURE 45

LIMITS OF PERFORMANCE OF COLLEGE CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 25 OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
16	9,2,23,24,15
3	9,15,18
1	18,24,8,4
7	1,10,23,26,18,17,15
9	9,23,2,24,20

Experimental

Subjects	Tactics
15	9,8,23,26,20
8	9,8,20
19	2,3,7,9,20
18	2,3,5,9,24,23,15
9	7,8,3,9,14,15,24

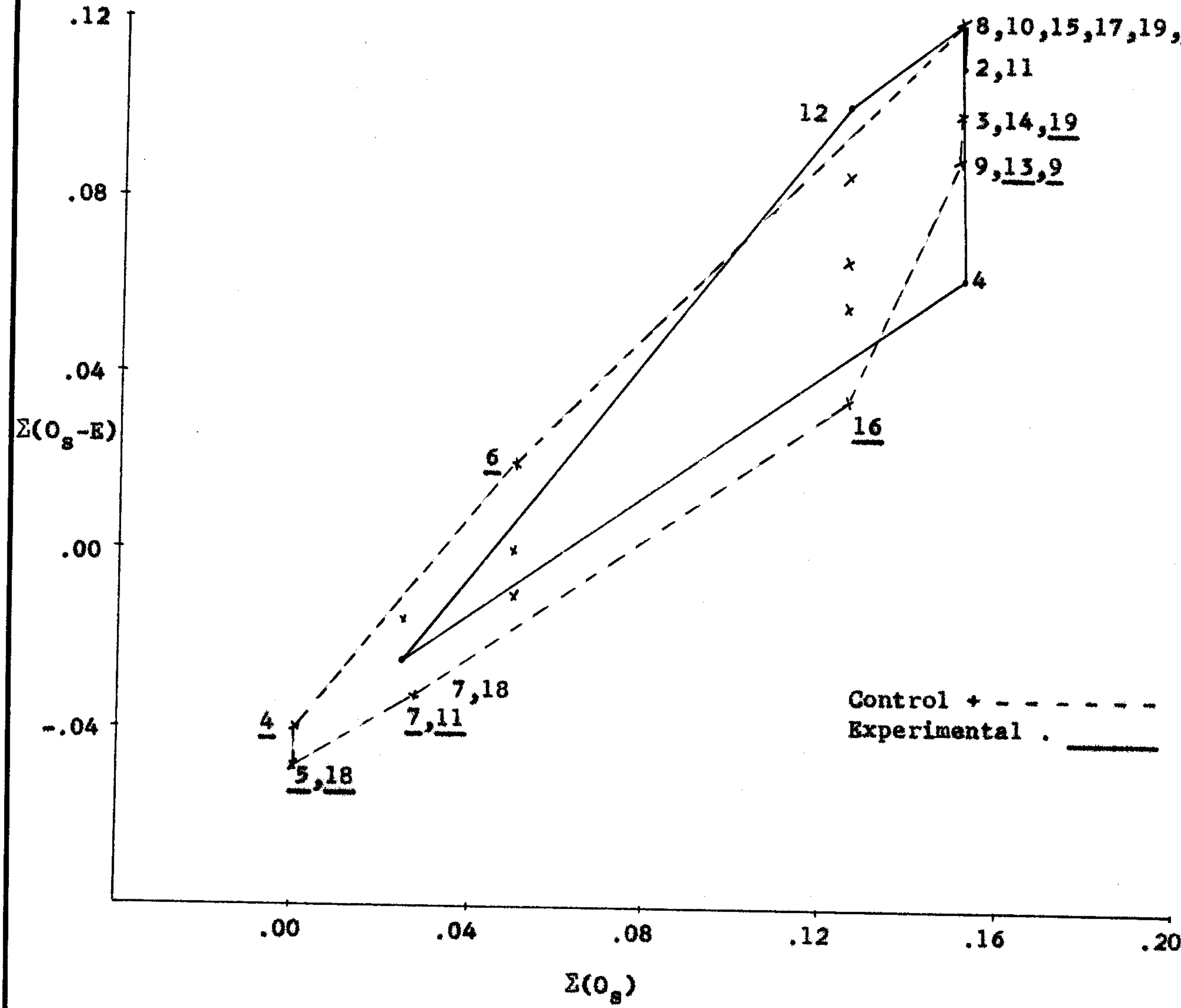

FIGURE 46

LIMITS OF PERFORMANCE OF HIGH SCHOOL CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 31D' OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
3	2,4,7
4	1,5,2,7
6	8,4,7
5	4,10,6,3,5
18	8,2,5,7,3
7	7,2,8,4,3,1
11	4,7,2,3,8,5
16	2,3,6,7,8,5,4,1,9,10
9,13	2,4,8,3,7,6
19	2,4,8,3,7

Experimental

Subjects	Tactics
8,10,15,17, 19	2,4,7
12	2,4
7	6,8,2,4,3
18	3,2,4,8,7
4	2,4,3,7,9,8,1,10,6
9	2,3,4,7,8,6
3	2,4,7,3,8
14	2,4,3,7,8
2	2,3,4,7
11	2,7,4,8

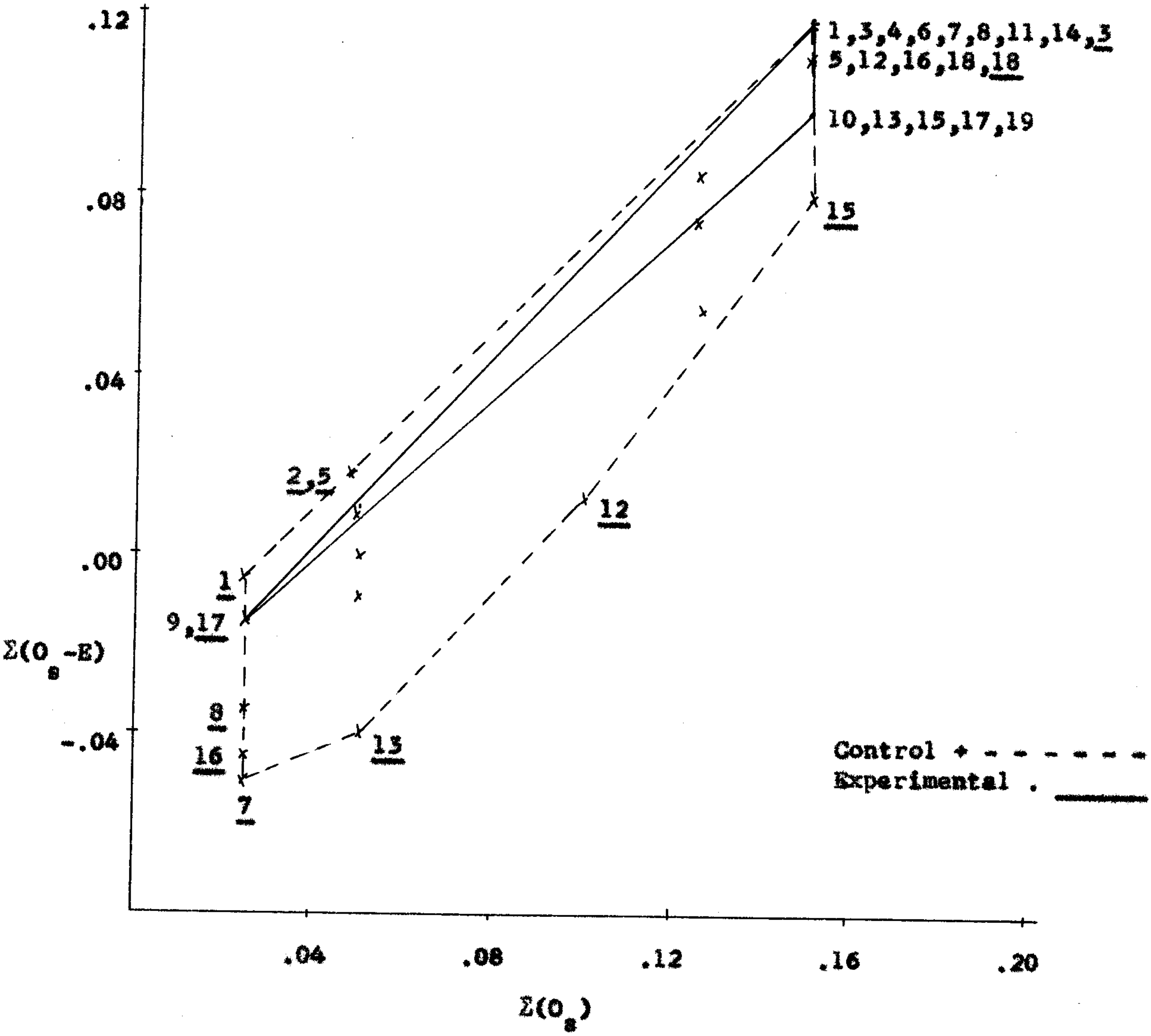

FIGURE 47

LIMITS OF PERFORMANCE OF COLLEGE CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 31D' OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control		Experimental	
Subjects	Tactics	Subjects	Tactics
3	2,4,7	1,4,7,11,14	2,4,7
2,5	6,7,8	3,6,8	2,3,8
1	7,2,4	9	6,2,4,7
17	7,2,8,4	10	2,3,7,4,8
8	6,2,3,4,7,8	13	2,4,7,8,3
16	8,1,7,3,5,6,4	15	2,4,3,8,7
7	4,7,2,8,6,3,5,9	17	2,3,7,8,4
13	3,8,7,6,4,2,1,5,9,10	19	2,4,8,7,3
12	2,5,6,7,4,3,9,8,10	12,18	2,7,8,3
15	2,3,4,8,6,7,5	5,16	2,4,3,7
18	2,7,8,3		

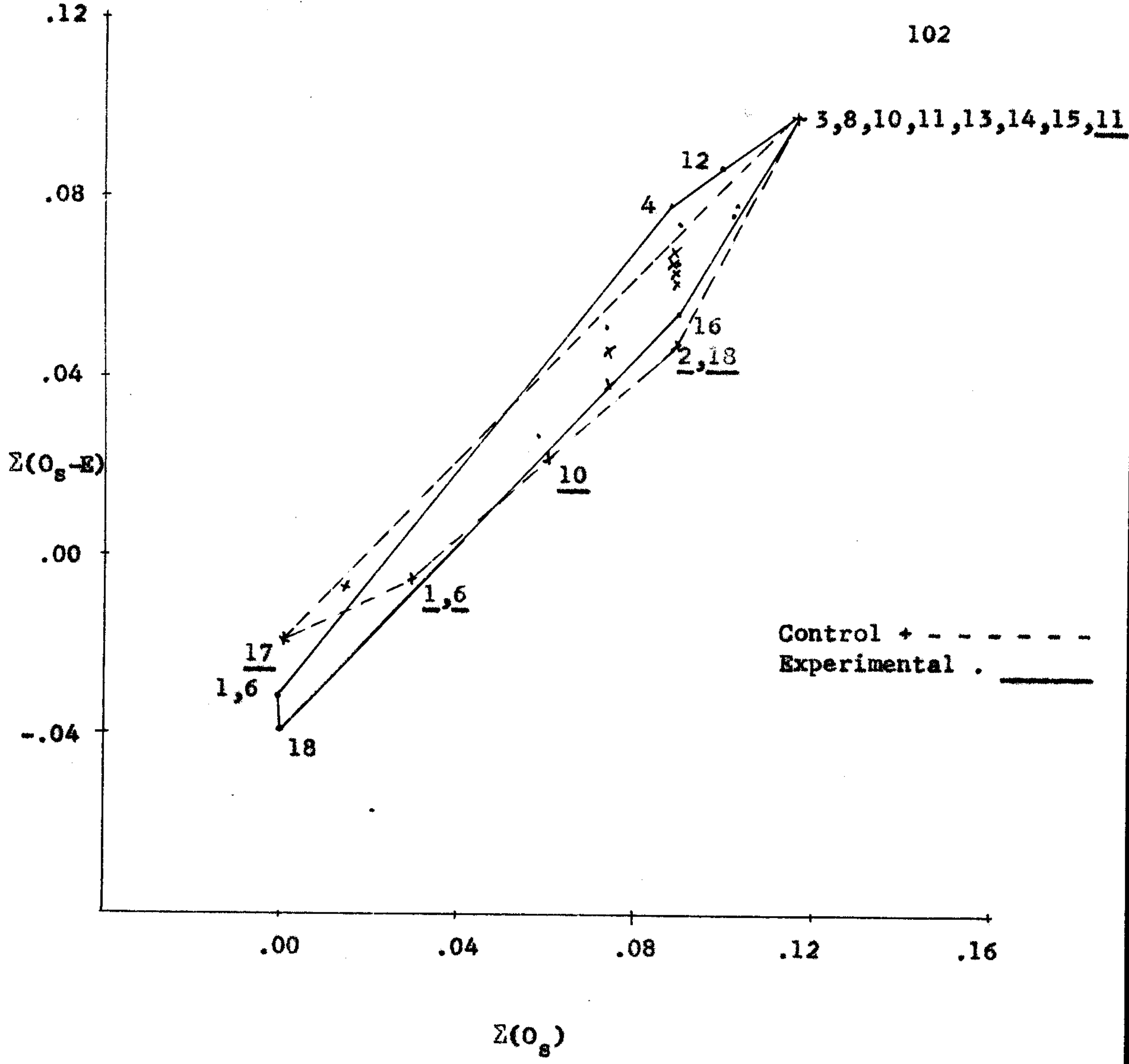

FIGURE 48

LIMITS OF PERFORMANCE OF HIGH SCHOOL CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 35B' OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control		Experimental	
Subjects	Tactics	Subjects	Tactics
11	5,15,6,13,4	3,15	5,6,15,13,4
17	2,5,4,6,8,15	8,10	5,15,6,4,13
1	1,2,3,4,5,6,7,8,9,10	11,13,14	5,6,15,4,13
6	2,4,5,11,13,14,16,15,	12	5,2,8,11
	8,6	4	5,6,11
10	5,7,14,6,2,13,15,11,9,	1	11,14,12,16,7,9,4,5,13
	16,12	6	7,5,4,6,8,15,2,14,11
2	5,2,7,15,11,6,4,8,14,12,13,9,	18	14,16,12,8,5,6,15,2,7,13,4
18	5,13,15,16,14,7,8,6,12,9,11,4	16	5,15,7,9,11,13,4,12,14,16

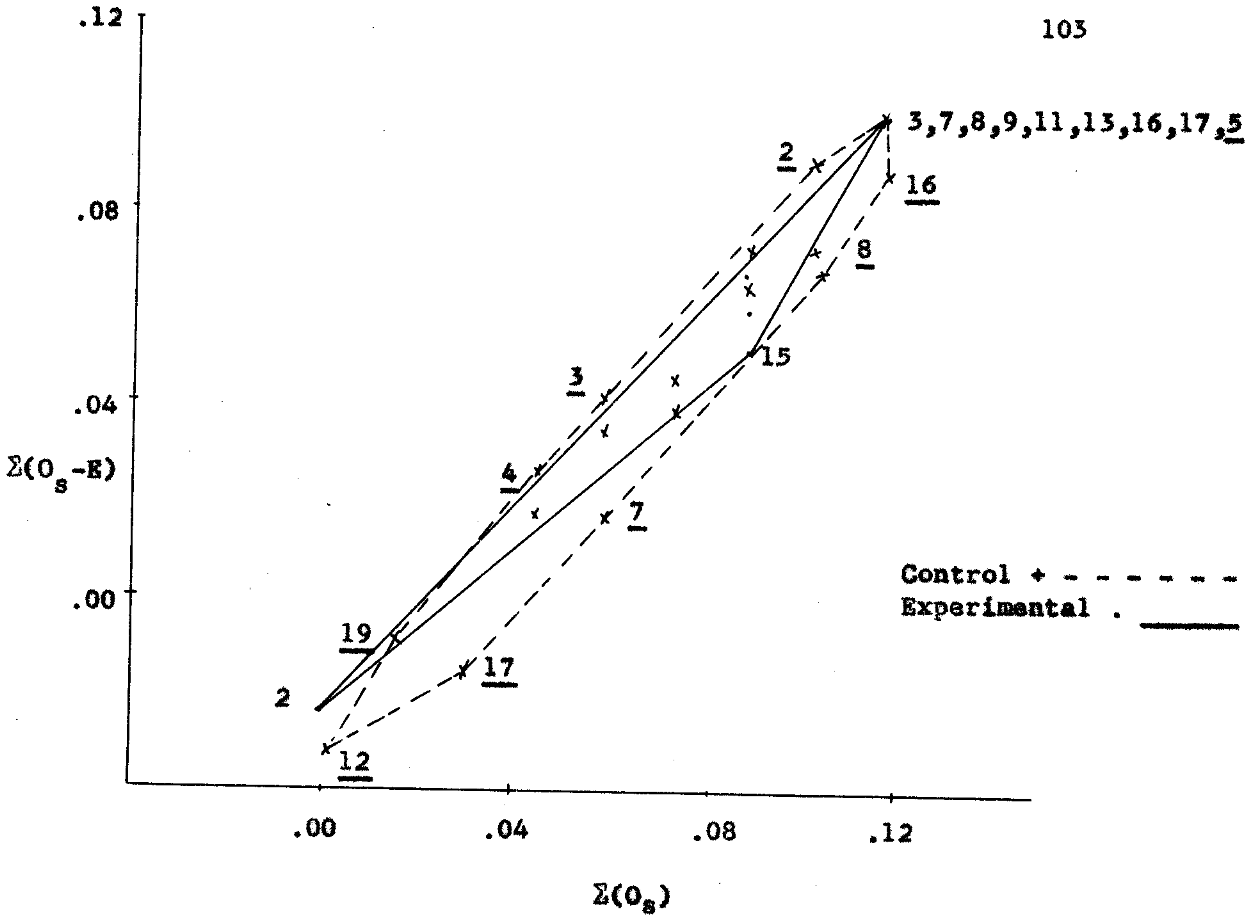

FIGURE 49

LIMITS OF PERFORMANCE OF COLLEGE CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 35B' OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
5	5,2,8,13,4
2	5,2,8,13
3	5,14,11,2,8
4	15,6,5,13,4
19	7,5,4,8,13,9,3
12	11,14,9,12,7,13,5,16,4
17	4,8,15,5,2,13,12,14,11, 6,7,9,16
7	5,14,11,8,6,15,4,16,12, 9,7,13
8	5,4,6,11,14,7,9,12,13,16
16	5,15,6,14,11,8,4,13

Experimental

Subjects	Tactics
3,9	5,6,15,4,13
7,13	5,6,15,13,4
8,12,16,17	5,15,6,4,13
11	5,2,8,14,11
2	14,11,5,6,15,4,13
15	5,15,2,7,6,11,16,8,4,13

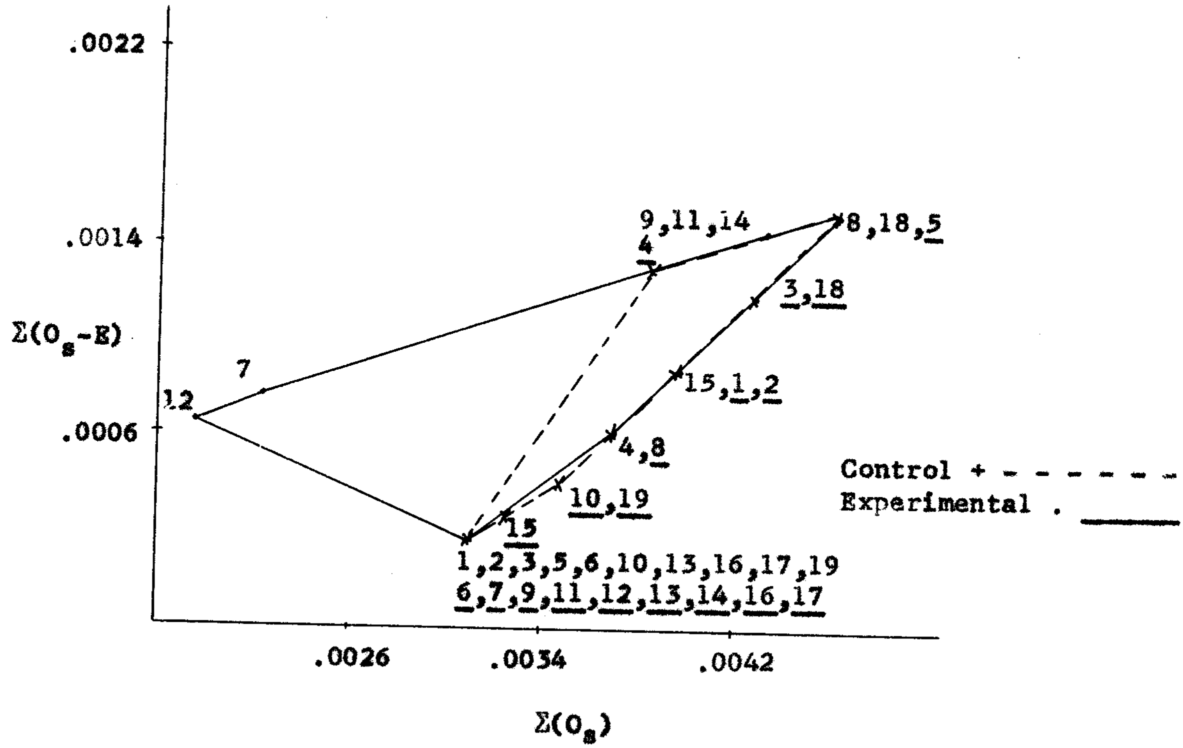

FIGURE 50

LIMITS OF PERFORMANCE OF HIGH SCHOOL CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 32F OF THE POST TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Number of Questions
5	12
4	10
6,7,9,11,12,13,14	
16,17	18
15	17
10,19	16
8	15
1,2	14
3,18	13

Experimental

Subjects	Number of Questions
8,18	12
9,11,14	11
7	6
12	5
1,2,3,5,6,10,13,16, 17,19	18
4	15
15	14

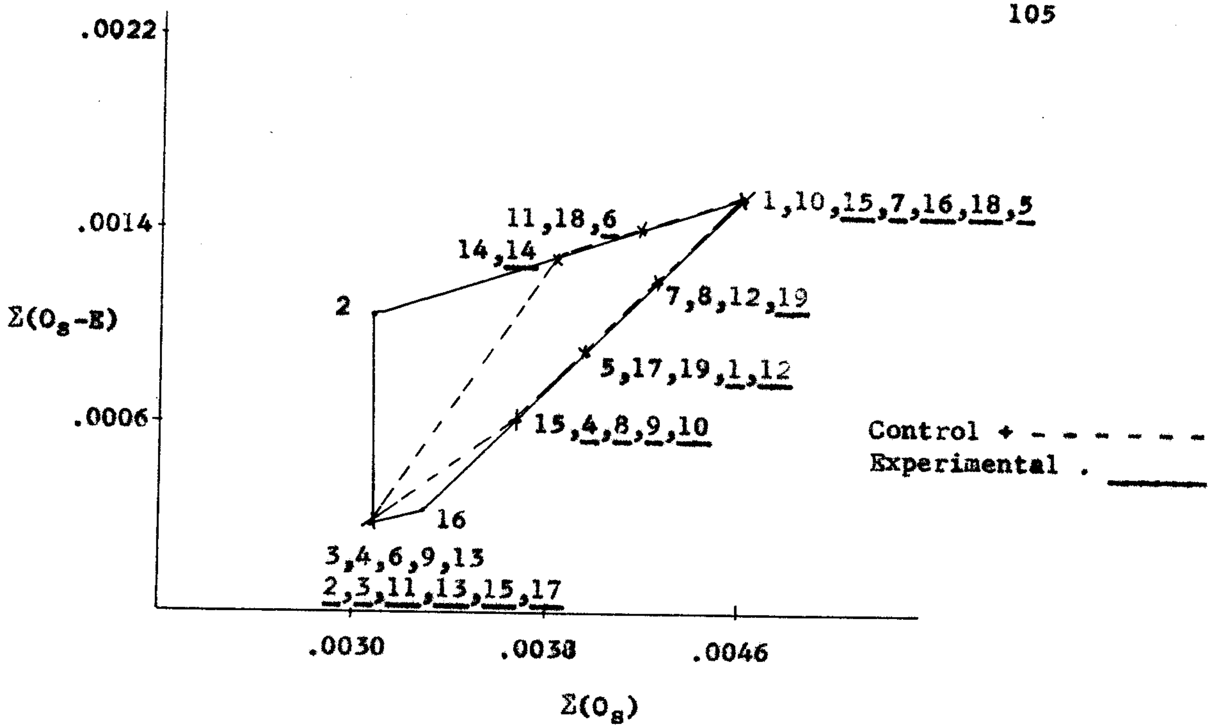

FIGURE 51

LIMITS OF PERFORMANCE OF COLLEGE CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 32F OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Number of Questions
5,7,15,16,18	12
6	11
14	10
2,3,11,13,15,17	18
4,8,9,10	15
1,12	14
19	13

Experimental

Subjects	Number of Questions
1,10	12
11,18	11
14	10
2	8
3,4,6,9,13	18
16	17
15	15
5,17,19	14
7,8,12	13

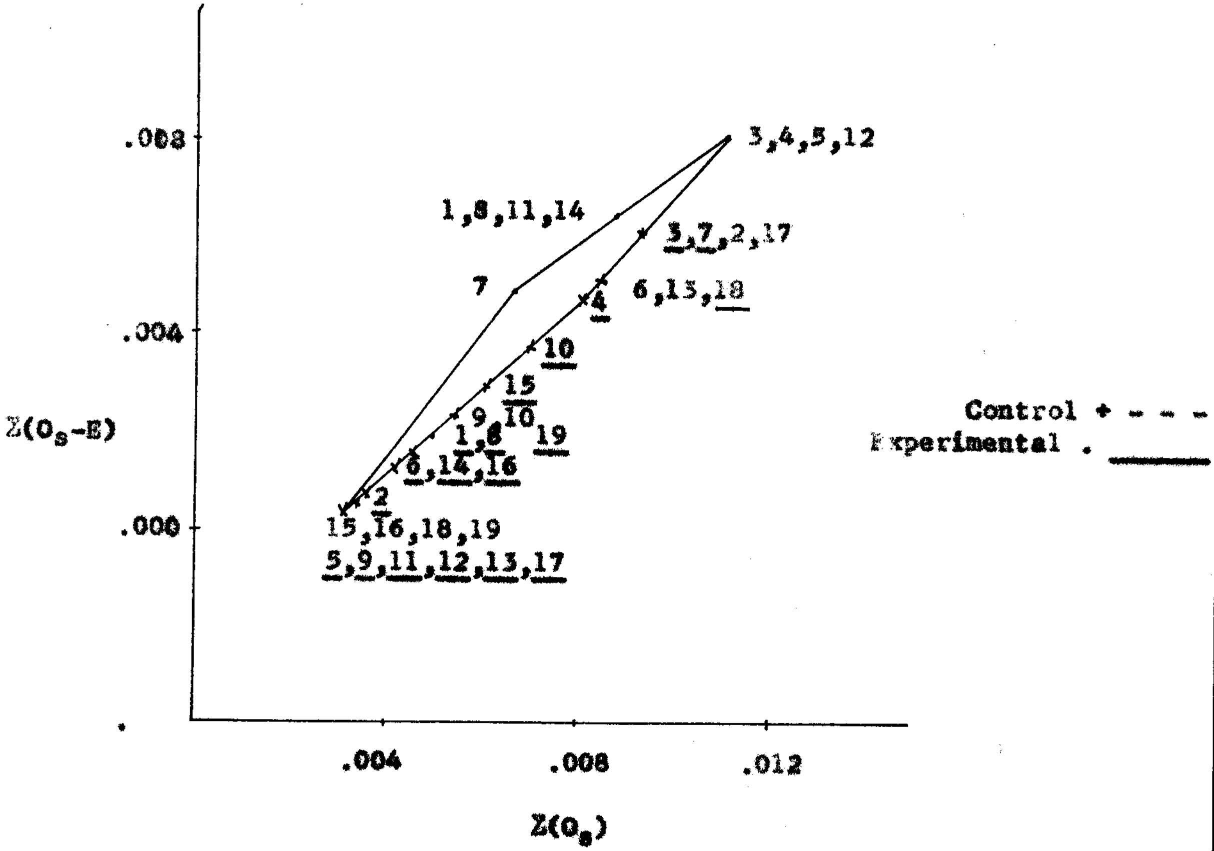

FIGURE 52

LIMITS OF PERFORMANCE OF HIGH SCHOOL CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 36F OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control	
Subjects	Number of Questions
5,9,11,12,13,17	18
2	17
6,14,16	16
1,8	13
19	12
15	10
10	9
4	8
18	7
3,7	6

Experimental	
Subjects	Number of Questions
3,4,5,12	5
1,8,11,14	4
7	3
15,16,18,19	18
9,10	11
6,13	7
2,17	6

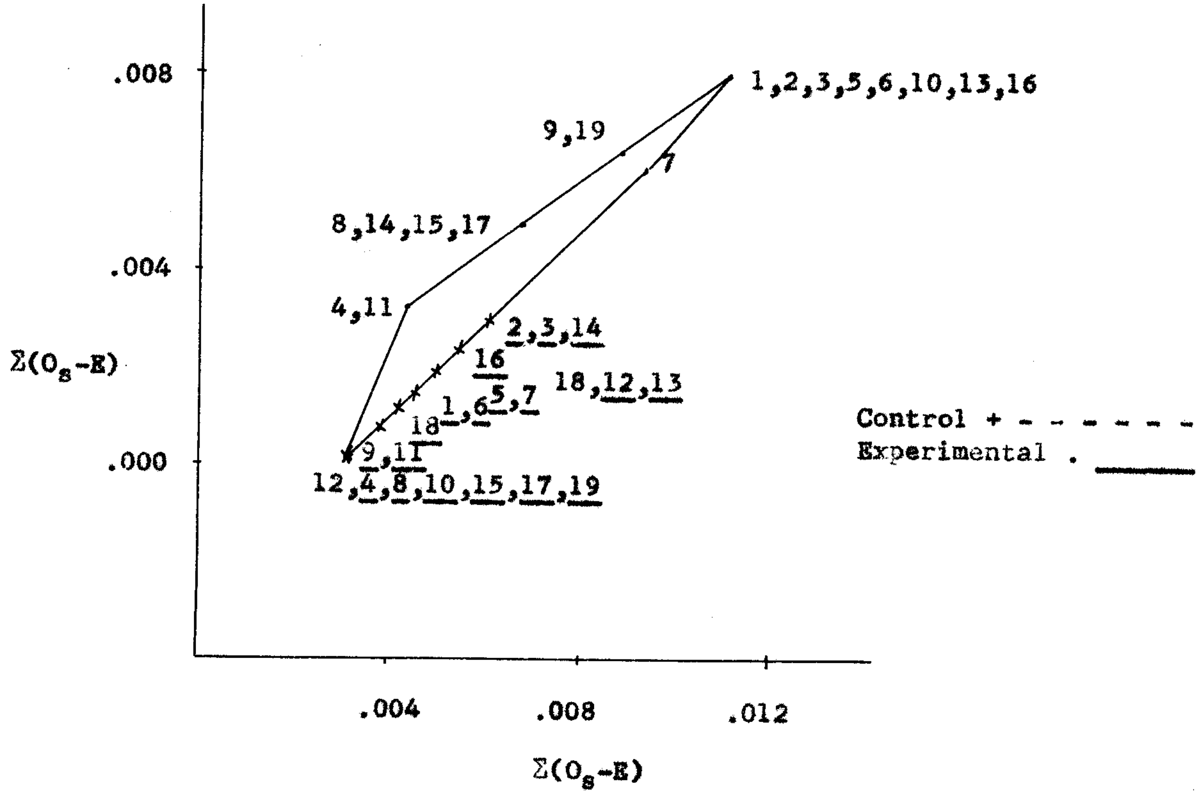

FIGURE 53

LIMITS OF PERFORMANCE OF COLLEGE CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 36F OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Number of Questions
4,8,10,15,17,19	18
9,11	17
18	14
1,6	13
5,7	12
12,13	11
16	10
2,3,14	9

Experimental

Subjects	Number of Questions
1,2,3,5,6,10,13,16	5
9,19	4
8,14,15,17	3
4,11	2
12	18
18	11
7	6

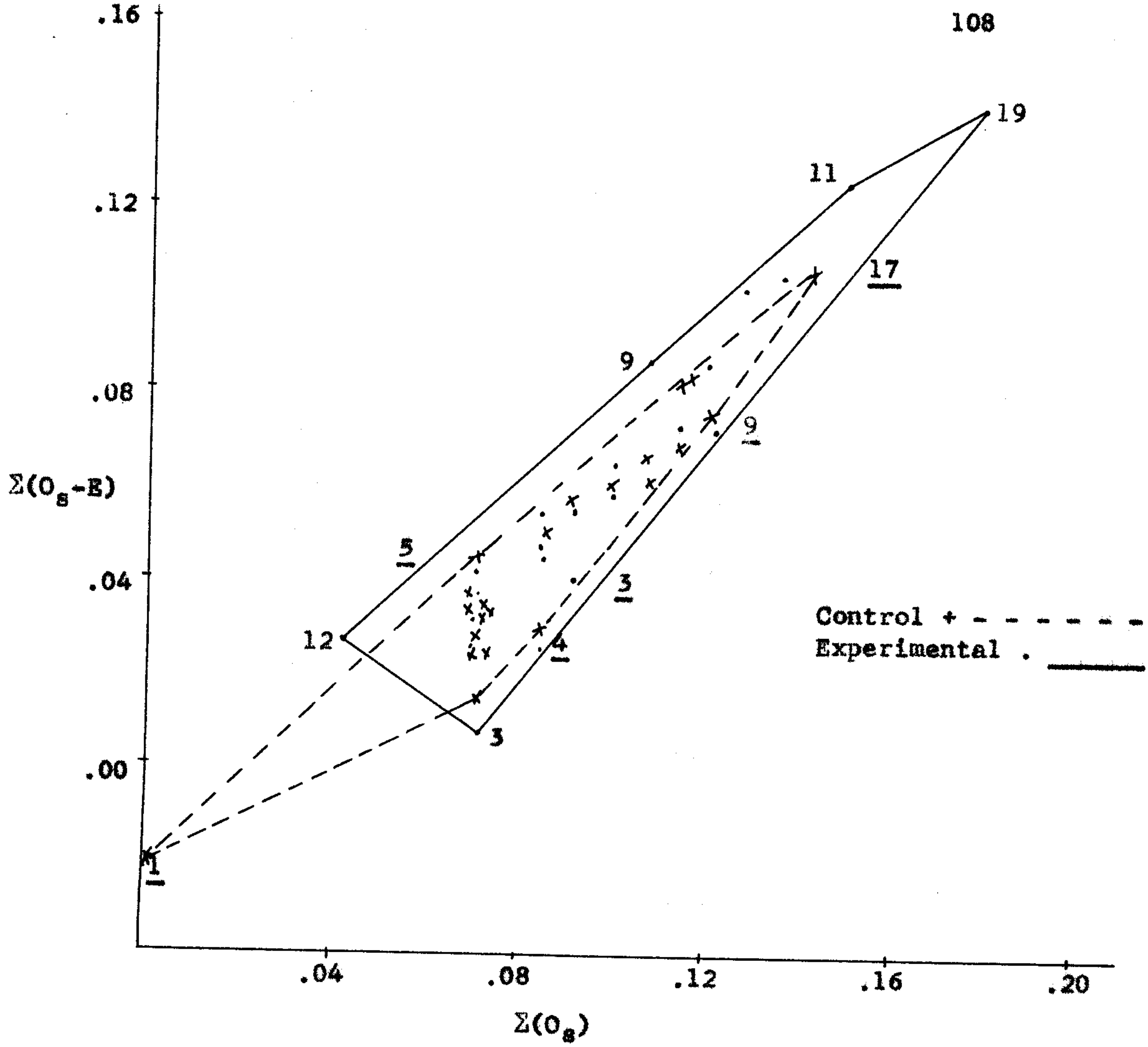

FIGURE 54

LIMITS OF PERFORMANCE OF HIGH SCHOOL CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 26 OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
17	1,2,6,7,8,9,5
5	1,2,3,4,7
1	12,10,5,11
4	1,2,3,4,11,12,13,9,6, 7,8
3	1,2,3,4,9,13,7,8,6,14, 12
9	1,9,7,2,3,4,12,11,10

Experimental

Subjects	Tactics
19	1,7,9,6,8,13,5
11	1,6,7,8,9
9	1,9,6,3,13
12	6,7,8
3	1,2,3,4,7,6,9,13,5,14, 11,10,8

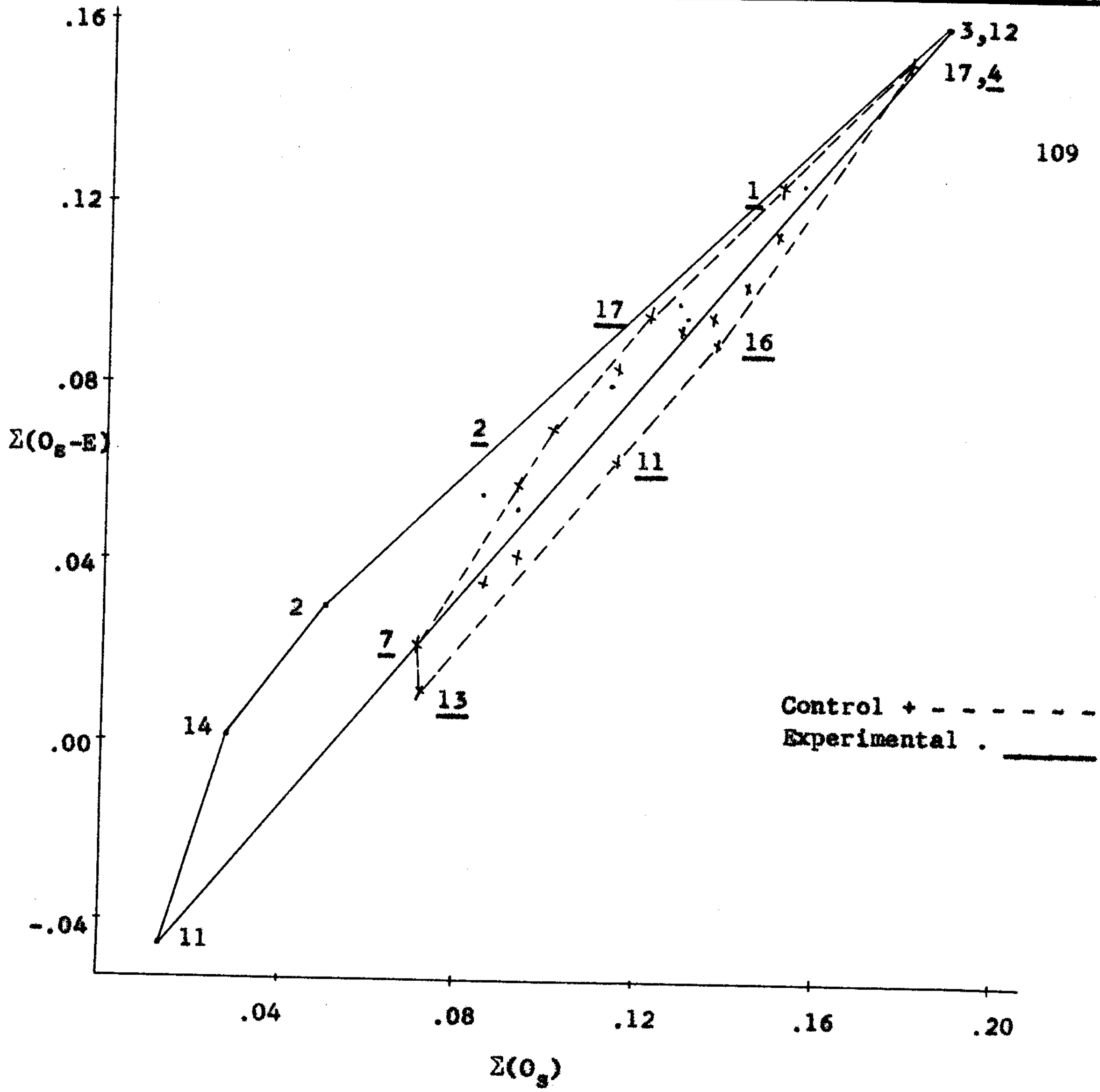

FIGURE 55

LIMITS OF PERFORMANCE OF COLLEGE CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 26 OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
4	1,7,9,6,8
1	1,6,7,8,9
17	1,9,8,3,6
2	1,3,8,2,9,6
7	1,10,11,12,2,4,3,6,7,8
13	1,10,11,12,2,3,4,6,5,9, 7,8
11	1,6,11,9,7,4,3,8,10,2
16	1,6,7,4,9,3,10,8,5

Experimental

Subjects	Tactics
3,12	1,9,7,6,8
2	9,7,3,6
14	7,14,13,8,9,2
11	6,10,11,8,12,14,3,7, 13,5,4,9
17	1,7,6,9,8

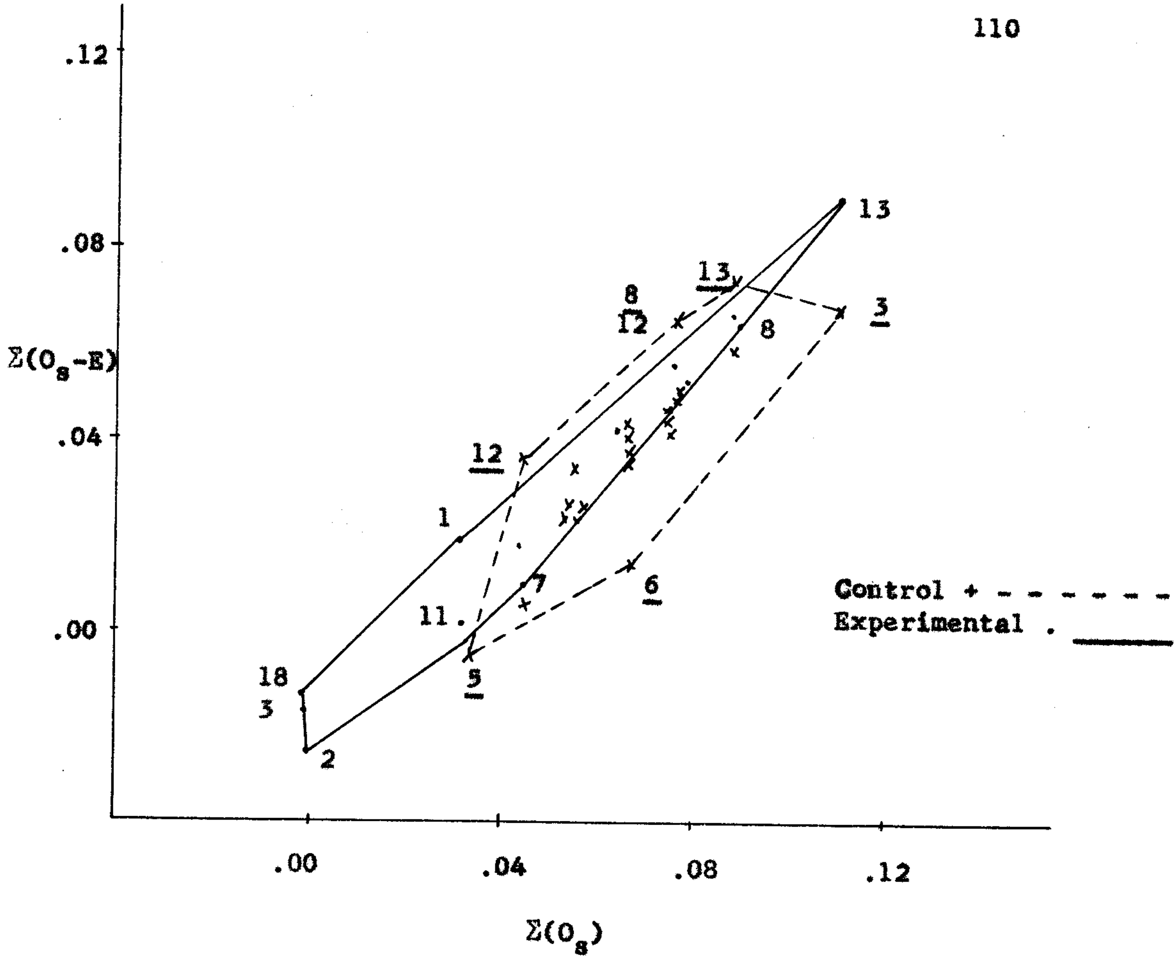

FIGURE 56

LIMITS OF PERFORMANCE OF HIGH SCHOOL CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 41A OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
13	1,5,6,3
8	1,5,6
12	1,5
5	15,13,4,1,3,6,14,8,5
6	1,4,6,10,11,12,3,5,15,14,13,2
3	1,5,6,11,3,15,13,4,8,9

Experimental

Subjects	Tactics
13	1,9,6,5,3
12	1,5,3,9
1	1,15,13
18	6,9,15
3	11,4,3,13
2	6,3,13,10,8,11
11	14,8,4,1,6,9,3,5
7	8,4,3,9,11,5,10,13
8	14,5,6,3,10,9

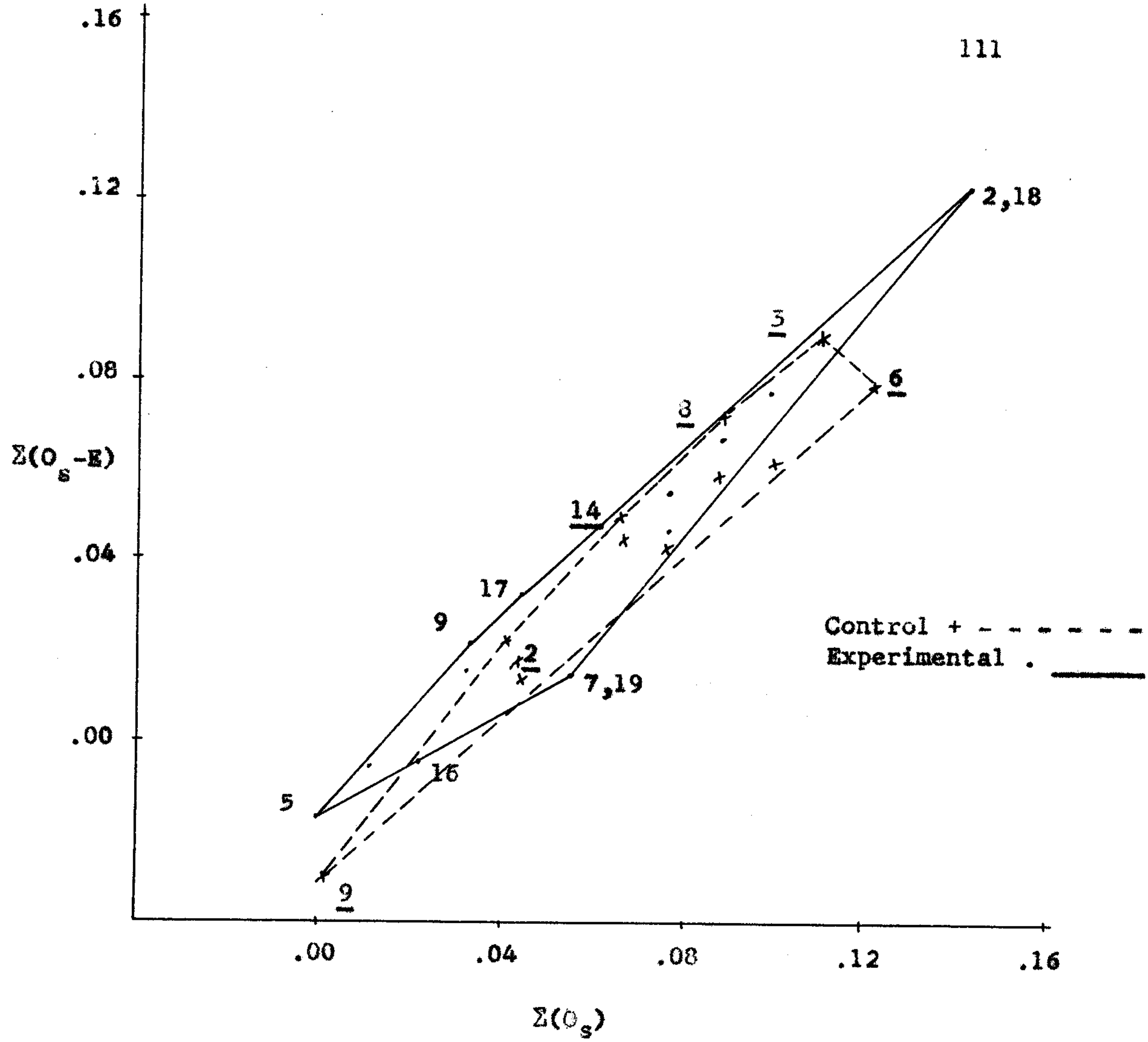

FIGURE 57

LIMITS OF PERFORMANCE OF COLLEGE CONTROL AND EXPERIMENTAL SUBJECTS ON PROBLEM 41A OF THE POST-TESTING SESSIONS BASED ON SCHEMATA NORMS

Control

Subjects	Tactics
3	1,6,9,3,5
8	1,5,6,3
14	1,3,9,6
2	6,3,5,9
9	5,14,13,8,6,9,3
6	14,1,6,10,8,3,11,2,13,5

Experimental

Subjects	Tactics
2,18	1,5,6,9,3
17	10,6,9
9	3,6,5
5	6,3,8,13
16	5,6,7,10,1,9
7	1,6,3,2,13,8,11,5,9
19	5,6,13,1,3,14,4,8,10

2. High school versus college students.

a) Length of plateaux.

In order to study the effect that a particular educational level may have on the performance of these problems, the length of plateaux that appears on the performance curve of high school and college students on the problems of the pre and post-testing sessions were compared.

Tables 14 and 15 present the mean and standard deviation of the length of plateaux and the "t" values for control and experimental high school and college students. These tables show that the mean for the length of plateaux is larger for high school than for college students with the exception of the control group on problem 36F.

For the control subjects the differences are significant at the .05 level for problems 1 and 19 of the pre-testing sessions, and, for problems 1, 25, and 26 of the post-testing sessions.

Table 15 shows that the differences for the experimental subjects are significant at the .05 level for problems 19 and 25 of the pre-testing sessions. For the post-testing sessions the differences are significant at the .001 level for problem 25, at .01 level for problems 31D' and 26, and at the .05 level for problem 36F.

In summary, it can be concluded that the college students approach the problems in a more "logical" manner than the high school students even if the differences do not always reach a significant level. Further, it seems that training has more effect on the college students than on the high school students.

TABLE XIV

MEAN AND STANDARD DEVIATIONS OF LENGTH OF PLATEAUX, NUMBER OF SUBJECTS AND "t" VALUES FOR EACH ONE OF THE PROBLEMS OF THE PRE-TESTING AND POST-TESTING SESSIONS ON THE HIGH SCHOOL AND COLLEGE CONTROL SUBJECTS

		High School			College			
Problems		M	σ	N	M	σ	N	"t" Values
Pre-Testing	1	1.95	1.54	19	.95	1.00	19	2.37*
	19	5.05	3.30	19	3.37	2.41	19	1.79*
	25	6.42	4.61	19	5.16	3.12	19	.99
Post-Testing	1	.84	.87	19	.32	.57	19	2.18*
	19	2.79	1.91	19	2.47	1.98	19	.51
	25	4.37	2.68	19	3.11	1.59	19	1.76*
Type a	31D'	3.95	2.09	19	3.37	2.52	19	.77
	35B'	5.68	2.51	19	5.05	3.14	19	.68
Type b	32F	4.00	2.25	19	2.79	2.44	19	1.58
	36F	8.58	4.48	19	9.21	3.46	19	- .49
New Problems	26	6.00	2.20	19	4.47	2.85	19	1.85*
	41A	4.26	2.59	19	3.47	2.28	19	1.00

*$p < .05$

TABLE XV

MEAN AND STANDARD DEVIATIONS OF LENGTH OF PLATEAUX, NUMBER OF SUBJECTS AND "t" VALUES FOR EACH ONE OF THE PROBLEMS OF THE PRE-TESTING AND POST-TESTING SESSIONS ON THE HIGH SCHOOL AND COLLEGE EXPERIMENTAL SUBJECTS

		High School			College			
Problems		M	σ	N	M	σ	N	"t" Values
Pre-Testing	1	1.58	1.84	19	1.05	1.32	19	1.02
	19	4.42	2.26	19	3.00	1.62	19	2.23*
	25	5.37	2.64	19	3.53	2.14	19	2.36*
Post-Testing	1	.95	1.70	19	.37	.74	19	1.36
	19	2.95	2.46	19	1.84	1.56	19	1.66
	25	5.21	2.80	19	2.74	1.33	19	3.47***
Type a	31D'	2.21	1.91	19	.95	.94	19	2.58**
	35B'	3.05	3.73	19	1.74	2.51	19	1.27
Type b	32F	3.42	2.82	19	2.47	2.44	19	1.11
	36F	3.68	5.13	19	1.05	3.08	19	1.92*
New Problems	26	5.32	3.14	19	3.00	2.70	19	2.44**
	41A	3.47	1.76	19	2.42	2.09	19	1.68

* $p < .05$
** $p < .01$
*** $p < .001$

b) Convex sets.

Comparing the convex sets for high school and college students for problem 1 of the pre-testing sessions (figures 34 and 35) show that the convex sets for the college students are higher than the convex sets for the high school students. On the same problem for the post-testing sessions (figures 40 and 41) the convex sets for college students show less dispersion than the convex sets for high school students.

In problems 19 and 25 of the pre and post-testing sessions (figures 36 to 39 and 42 to 45) the convex sets for college students show less dispersion than the convex sets for high school students.

In problem 31D' the convex sets for college experimental subjects (figure 47) show less dispersion than the convex sets for the high school students (figure 46). Further, 17 college experimental subjects have the higher (0_s) score whereas only 11 high school experimental subjects have the higher (0_s) score. On the convex sets for control subject not much differentiation is found.

The convex sets for problems 35B', 32F and 36F show little differentiation between high school and college subjects (figures 48,49,50, 51, 52 and 53).

The convex sets for problem 26 (figures 54 and 55) show larger dispersion in terms of the (0_s-E) values for the experimental college subjects than for the high school experimental subjects. Comparing the control subjects the convex sets for the high school students shows more dispersion than the convex sets for the college students.

The convex sets for problem 41A (figures 56 and 57) show larger values for college than for high school students in both control and experimental subjects. As a general statement it can be said that the college students show "better" performance than the high school students on approaching these problems.

CHAPTER V

SUMMARY AND CONCLUSIONS

This research has been designed in order to study individual differences in thought processes. Its primary interest was to study the process followed by the subject in order to reach the solution of the problem. For this purpose the performance of 38 experimental subjects were studied throughout 24 problems of the training sessions.

The methods used to perform the study of this first part of the research were: group norms, length of plateaux calculated from the schemata norms, and performance curves based on group norms and on schemata norms.

Of special interest was the study of the complexity of the problems represented by the schemata and the degree of abstraction of the content. The analysis of variance using group norms and length of plateaux show that the main effect schemata and the main effect content are statistically significant. The interaction between schemata and content is also significant.

When comparing the performance curves based on group norms with the ones based on schemata norms, it is clear that the latter gives more useful information about the process followed by the subject when he is solving a problem.

The second aim of this research was to study the individual differences in the process of solving a problem between subjects with training and subjects without training. For this purpose,the performances of 38 experimental subjects were compared with the performances of 38 control subjects individually matched before the experiment. These comparisons were made on the basis of 12 problems, 3 pre-testing and 9 post-testing.

The methods used to measure their performance were: schemata norms, length of plateaux, individual performance curves based on schemata norms, and convex sets based on schemata norms. The experimental subjects show a "better" performance than the control subjects. When the experimental subjects had any plateaux at all, they were shorter than the plateaux of the control subjects.

The individual performance curves show that the process followed by the experimental subjects in order to solve a problem is "better" than the one followed by the control subjects. This means that the experimental subjects always approach the problems in a more "logical" way. The greatest differences were found in the problems similar to those used in the training sessions.

The third aim of this research was to study whether the educational level had an influence on the process followed by a subject in order to solve this type of problems. The study of the length of the plateaux shows clearly that the process followed by the college students is always "better" than the one followed by the high school students.

The results of the present research confirm the one obtained on the previous one (Rimoldi, Fogliatto, Haley, Reyes, Erdmann, Zacharias, 1962). The control and experimental subjects were compared on the number of questions they used in order to solve the problems and compared on the agreement concerning the questions they should ask. The results of the comparison between college and high school students is also confirmed.

The methods used in the present research are more sensitive than the methods used on the previous research. The schemata norms give more clear information on the process followed by a subject in order to solve a problem than the group norms. More sensitive even than the study of the accumulative score according to schemata norms is the study of length of plateaux.

Plateaux are found in that stage of a subject's performance when he asks either irrelevant questions or relevant questions out of their proper order. Thus, the length of a plateau is measured by the number of irrelevant or out-of-order questions selected in sequence. This measure may be interpreted in several ways. One would simply be an indication of the subject's lack of progress toward a solution. It might also be a period in which the subject is reformulating the problem. Likewise, it could merely represent a type of non-good-directed behavior during which the subject is "groping" for a possible clue. Regardless of the interpretation, the length of plateaux has shown itself to be an effective measure in the characterization of process.

The study of the convex sets using schemata norms also give clear information on the process followed by a subject in solving a problem, and also permits one to compare two groups of subjects.

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A P P E N D I X

Problem 19

Instructions and Corresponding Questions and Answers

John Smith lives in a small city that has only three companies. These are the Grant Co., the Williams Corporation, and the Gibbons Metals. Your task is to determine, if you can, which company John Smith works for. A set of questions regarding John Smith and the three companies is presented on the cards. The answer to each question is on the reverse side of the card. Look over all the questions and then decide which question you would first like to have answered and tell the examiner. Then turn over the card; read the answer and decide which question you would next like to have answered. Tell the examiner its number and turn over the card. Proceed in this way until you are satisfied that you have the answer to the problem. You may use as many questions as you feel you need to answer the question. However, do not use more questions than you feel you need.

	Questions		Answers
1.	What is Mr. Smith's salary?	1.	His salary is $8000 per year.
2.	How much education has he had?	2.	He is a high school graduate. He wanted to go to college, but his family did not have enough money to send him.
3.	Is Mr. Smith married or single?	3.	Mr. Smith is married. He has three children.
4.	How old is Mr. Smith?	4.	He is 46 years old.
5.	What kind of job does he have?	5.	He is Supervisor of a loading dock.
6.	How long has he had his present job?	6.	He has had his job for 11 years.
7.	How long has he lived in his present home?	7.	He has been in his present home for 6 years.
8.	What is the name of the city?	8.	The name of the city is Springton.
9.	Where in the city does Mr. Smith live?	9.	He lives at the North End of the city near the high school.
10.	How many banks are there in the city?	10.	There are two banks: the First National and the State Bank.
11.	Does Mr. Smith have a bank account?	11.	No, Mr. Smith does not have a bank account
12.	Where is the Grant Co.?	12.	The Grant Co. is just west of the city, off the main highway.
13.	Where is the Williams Corp.?	13.	The Williams Corp. is north of the city, just across the river.
14.	Where is Gibbons Metals?	14.	Gibbons Metals is near the center of the city.

Problem 19
(Continued)

Questions	Answers
15. How long has Grant and Co. been in the city?	15. Grant Co. is the oldest firm in the city. It has been there over 60 years.
16. How long has the Williams Corp. been in the city?	16. The Williams Corp. has been in the city about 15 years.
17. How long has Gibbons Metals been in the city?	17. Gibbons Metals opened its plant in this city 4 years ago.
18. How much education does Grant Co. require of its employees?	18. The policy of Grant Co. in recent years has been to hire only college graduates. As a result, all employees under 40 are college graduates. Some of the employees over 40 are only high school graduates, while some others are college graduates.
19. How much education does the Williams Corp. require of its employees?	19. The Williams Corp. hires only college graduates for supervisory positions. Employees below supervisor may be high school graduates only.
20. How much education does the Gibbons Metals require of its employees?	20. Gibbons Metals has no policy on education. Its employees may have any amount of education.

Solution: Mr. Smith works for the Grant Co.

Problem 25

Instructions and Corresponding Questions and Answers

The figure here is composed of overlapping geometric figures and lines, forming twenty-five areas. You will notice that an area is any enclosed part of the figure that does not have a line through it. One of the areas has been picked at random. Your task is to find out which one it was. To find the particular area, you must discover enough facts about it so that it can be distinguished from other areas. You may discover these facts by using any of the questions you like.

Proceed by reading over all the questions. Then decide on the first question you would like to have answered, and write its number on the page provided. Then take the card from the folder, and read the answer on the back of the card. After having read the answer, decide on the next question you would like to have answered. Write down its number and take the card from the folder. When you are satisfied that you have arrived at the answer, stop drawing cards, and write down your answer. Remember, you may use as many of the cards as you need to find the correct area, but don't draw any more than you need.

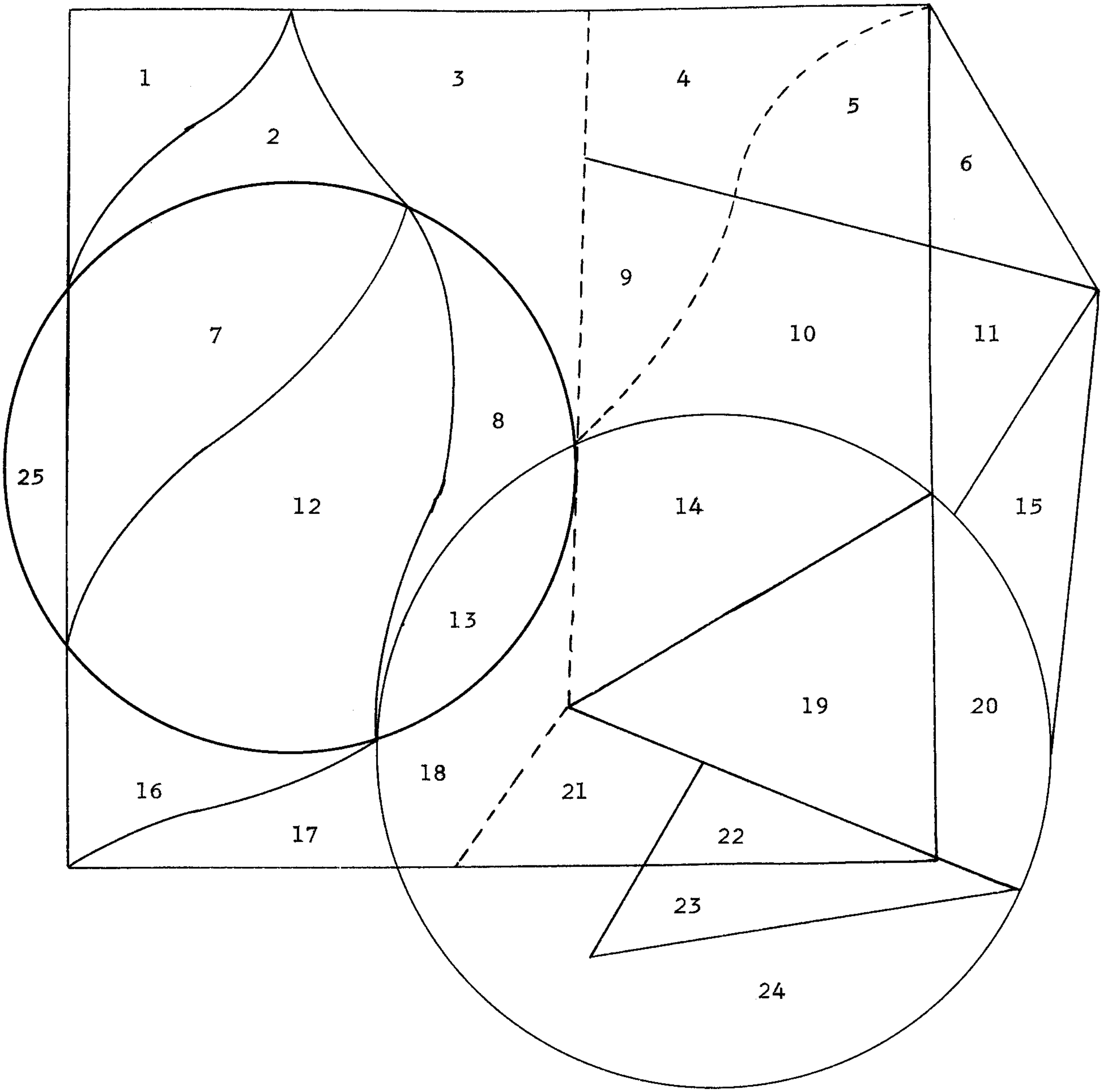
Questions	Answers
1. Is it in the large square?	1. Yes, it is in the large square.
2. Is it in the large circle?	2. No, it is not in the large circle.
3. Is it in the small circle?	3. No, it is not in the small circle.
4. Does the area have at least one right angle?	4. No, it does not have at least one right angle.
5. Is the area a rectangle?	5. No, the area is not a rectangle.
6. Is the area a triangle?	6. No, the area is not a triangle.
7. Is it outside the large square?	7. No, it is not outside the large square.
8. Is it outside the large circle?	8. Yes, it is outside the large circle
9. Is it to the left of the straight dotted line?	9. No, it is not to the left of the straight dotted line.
10. Is it to the right of the straight dotted line?	10. Yes, it is to the right of the straight dotted line.
11. Does it have all straight line boundaries?	11. No, it does not have all straight line boundaries.
12. Does it have all curved boundaries?	12. No, it does not have all curved boundaries.
13. Does the area have at least two boundaries?	13. Yes, the area does have at least two boundaries.
14. Does the area have at least three boundaries?	14. Yes, the area does have at least three boundaries.
15. Does the area have at least four boundaries?	15. Yes, the area does have at least four boundaries.

Problem 25
(Continued)

Questions	Answers
16. Does the area have at least five boundaries?	16. No, the area does not have at least five boundaries.
17. Does it have at least two straight line boundaries?	17. Yes, it has at least two straight line boundaries.
18. Does it have at least three straight line boundaries?	18. No, it does not have at least three straight line boundaries.
19. Does it have at least four straight line boundaries?	19. No, it does not have at least four straight line boundaries.
20. Does it have at least two curved boundaries?	20. Yes, it does have at least two curved boundaries.
21. Does it have at least three curved boundaries?	21. No, it does not have at least three curved boundaries.
22. Does it have at least four curved boundaries?	22. No, it does not have at least four curved boundaries.
23. Does it have a dotted boundary?	23. Yes, it does have a dotted boundary.
24. Does it have two dotted boundaries?	24. No, it does not have two dotted boundaries.
25. Does it have a straight line boundary?	25. Yes, it does have a straight line boundary.
26. Does it have a curved boundary?	26. Yes, it does have a curved boundary.

Solution: The pre-selected area is #10.

Problem 25



Problem 31A

Instructions and Corresponding Questions and Answers

At Spencer High School the annual fall dance is about to be held. A dance committee has been selected to make the necessary arrangements. Both boys and girls are on the committee. A part of the committee is to take care of the refreshments for the evening and another part will look after the sale of the tickets for the dance. The list of the girls on the dance committee involved in the sale of tickets has been lost. From the other information available, which you will find in the questions, your object will be to discover the number of girls involved in the sale of tickets.

Questions	Answers
1. Is Spencer High School the only coeducational school in the city?	1. No.
2. How many boys attend Spencer High?	2. 240 boys attend Spencer High.
3. How many boys are on the dance committee?	3. 10.
4. Are there more girls than boys at this school?	4. Yes.
5. How many students on the dance committee are assigned to supplying the refreshments?	5. 14.
6. What is the total number of students on the fall dance committee?	6. 25.
7. How much time would the committee as a whole spend in preparation for the dance?	7. 275 hours.
8. How much time would the average committee member contribute?	8. 11 hours.
9. How many boys on the committee are involved in the sale of tickets?	9. 6 boys.
10. How many girls are on the refreshment part of the dance committee?	10. 10 girls.

Solution: 5 girls.

Problem 31B

Instructions and Corresponding Questions and Answers

We have a certain number of objects, M, a part of which, for lack of a better name, will be called C's. The C's are composed of B's and G's. No B is a G and vice versa. Some of the C's also are R's and some others are T's. No R is a T and vice versa. How many G's are also T's?

Questions	Answers
1. Are there C's that are not B's and G's?	1. No.
2. How many B's are C's?	2. 30.
3. How many B's are M's?	3. 120.
4. How many C's are R's?	4. 35.
5. Are there more G's than B's among the M's?	5. Yes.
6. What is the value of k times the C's?	6. 550.
7. What is the total number of C's?	7. 50.
8. How many B's that are C's are also T's?	8. 10.
9. How many G's that are C's are also R's?	9. 15.
10. What is the value of k?	10. 11.

Solution: 5 G's.

Problem 31C

Instructions and Corresponding Questions and Answers

Assume that X, A, D, P, and S, represent properties among F objects. Not-X, not-A, and so on represent lack of these properties. Out of F objects some of them are X's and some not-X's. The not-X's are formed by not-A's and not-D's. A not-A can not be a not-D and vice versa.

Some of the not-X's also are not-P's and some others are not-S's. A not-P can not be a not-S and vice versa.

How many not-D's are also not-S's?

Questions	Answers
1. Are there not-X's that are A's and D's?	1. No.
2. How many not-A's are F's?	2. 100.
3. Are there more not-D's than not-A's among the F's?	3. Yes.
4. How many not-A's are not-X's?	4. 14.
5. What is the total number of not-X's?	5. 40.
6. How many not-X's are not-P's?	6. 24.
7. What is the value of 1 times the not-X's?	7. 440.
8. What is the value of 1?	8. 11.
9. How many not-D's that are not-X's are also not-P's?	9. 20.
10. How many not-A's that are not-X's are also not-S's?	10. 10.

Solution: 6 not-D's.

Problem 31D

Instructions and Corresponding Questions and Answers.

From R objects L have been selected. These objects are formed by A and B objects. No A can also be a B and vice versa. Some of the L objects are also M and some others N. No M can also be an N and vice versa.

How many N's are also B's?

Questions

1.	How many A's are R's?	1.	W.
2.	What is the total number of L's?	2.	E+F+H+I = X+Y = P+Q = L
3.	How many L's are M's?	3.	E+F = X
4.	How many A's are L's?	4.	E+H = P
5.	Are there more B's than A's among the R's?	5.	Yes.
6.	Are there L's that are not B's and A's?	6.	No.
7.	How many B's that are L are also M?	7.	F.
8.	How many A's that are L are also N?	8.	H.
9.	What is the value of K?	9.	T.
10.	What is the value of K times the L's?	10.	Z.

Solution: I

Instructions for Problems 36 A, B, C, D.

Each of the areas in the accompanying figure are identified by means of the number found printed in them. These numbers are merely for the purposes of indicating the particular area being discussed and have no bearing on the solution of the problem whatsoever.

The problem then is this. Each area has been assigned a symbol other than the above identifying numbers according to a predetermined plan. Your task will be to discover the symbols belonging to the areas which have their identifying numbers circled. This may be accomplished by asking the symbols for any area other than the ones circled. Decide which area you would like to know first. Then ask for its symbol. Continue working in this fashion until you feel you have sufficient information to specify accurately the symbols for the areas with the circled numbers.

Note: The rationales underlying the assignment of symbols to the various areas is as follows:

Problem 36A - The value of a particular area depends upon the color of the borders of the area. The value of each border of an area were summed to get the value of the area. One blue border has a value of "a" and one red border has a value of "b". Thus the value of area "2" is 2a + 2b.

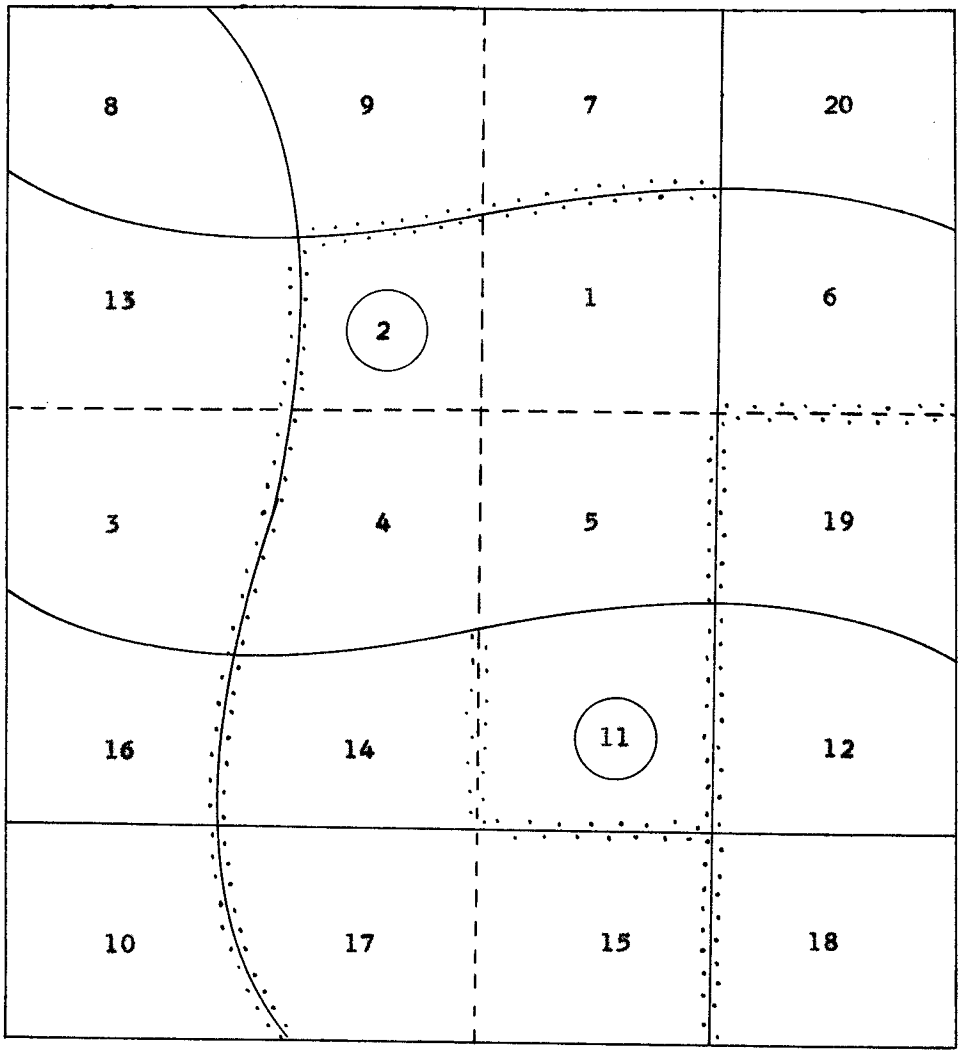
Problem 36 B - The value of a particular area depends upon the type of borders of each area. The values of each border of an area were summed to get the value of the area. A straight border has a value of "a", a dotted border has a value of "b", and a curved border has a value of "c". Thus the value of area "1" is a + B + 2c.

Problem 36 C - The value of a particular area depends upon the color and the type of borders of the area. The values of each border of an area were summed to get the value of the area. A blue straight border has the value of "a"; a blue dotted border, the value of "b"; a blue curved border, "c:; a red straight border, "d"; a red dotted border, "e"; and a red curved border, "f". Thus the value of area "17" is a + b + c + f.

Problem 36D - The value of a particular area depends upon the color and the type of borders of the area. The values of each border of an area were algebraically summed to get the value of the area. Blue borders have the same values as in Problem 36 C. A straight red border has the value of "-a"; a dotted red border, "-b"; and a curved red border, "-c". Thus the value of area "19" is a + c - b - c.

Solutions: Problem 36 A - 2 = 2a + 2b, 11 = a + 3b.
Problem 36 B - 1 = a + b + 2c, 17 = 3a +c.
Problem 36 C - 6 = a + b + c + f, 2 = c + 2d + e.
Problem 36 D - 15 = a + b + c - c, 8 = c - 2a -b.

Problem 36A



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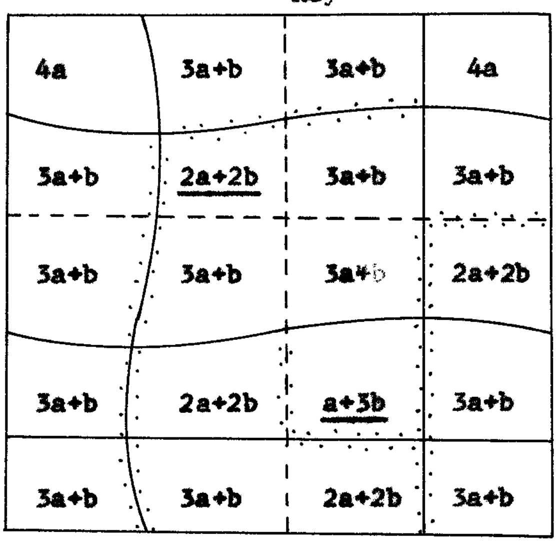
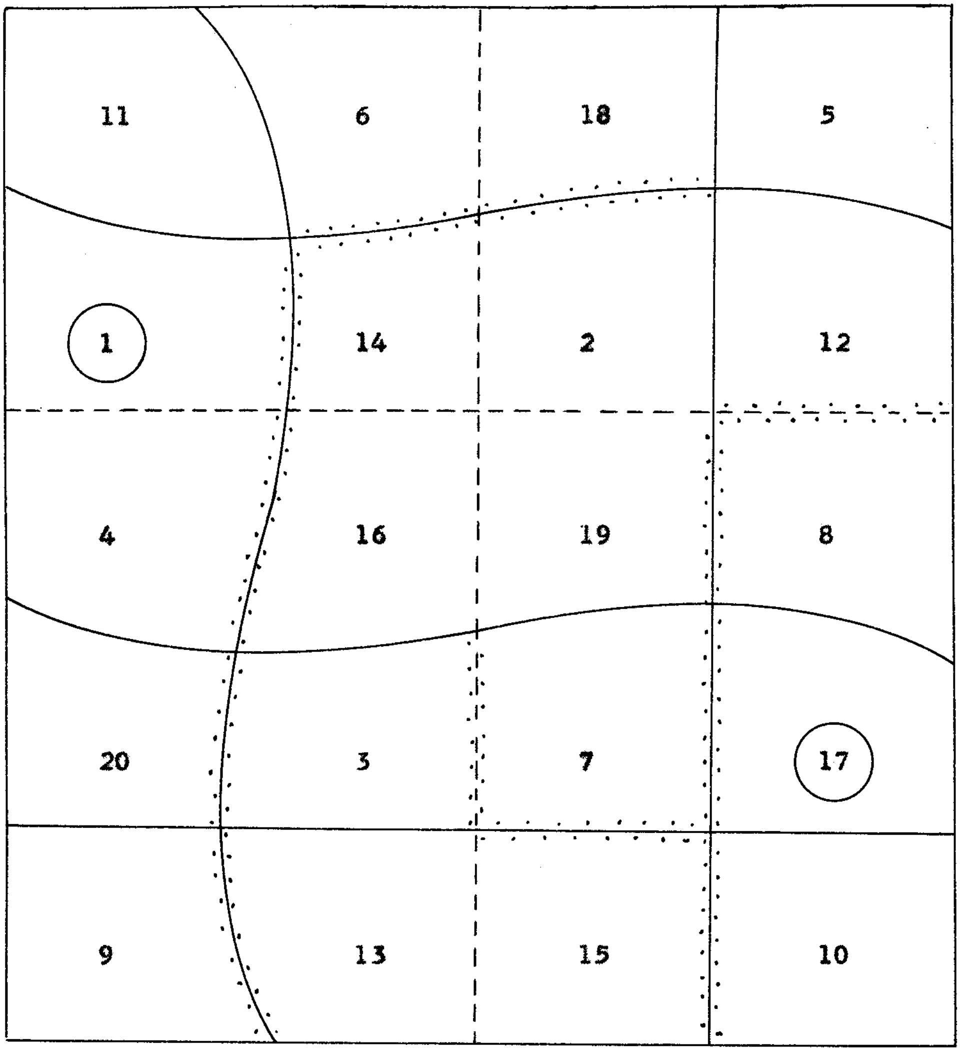


Note: lines or portions with dots along both sides appeared in red in the original.

Problem 36B



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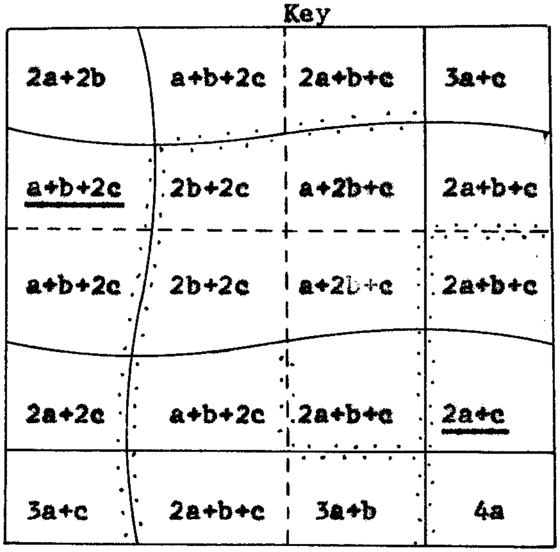

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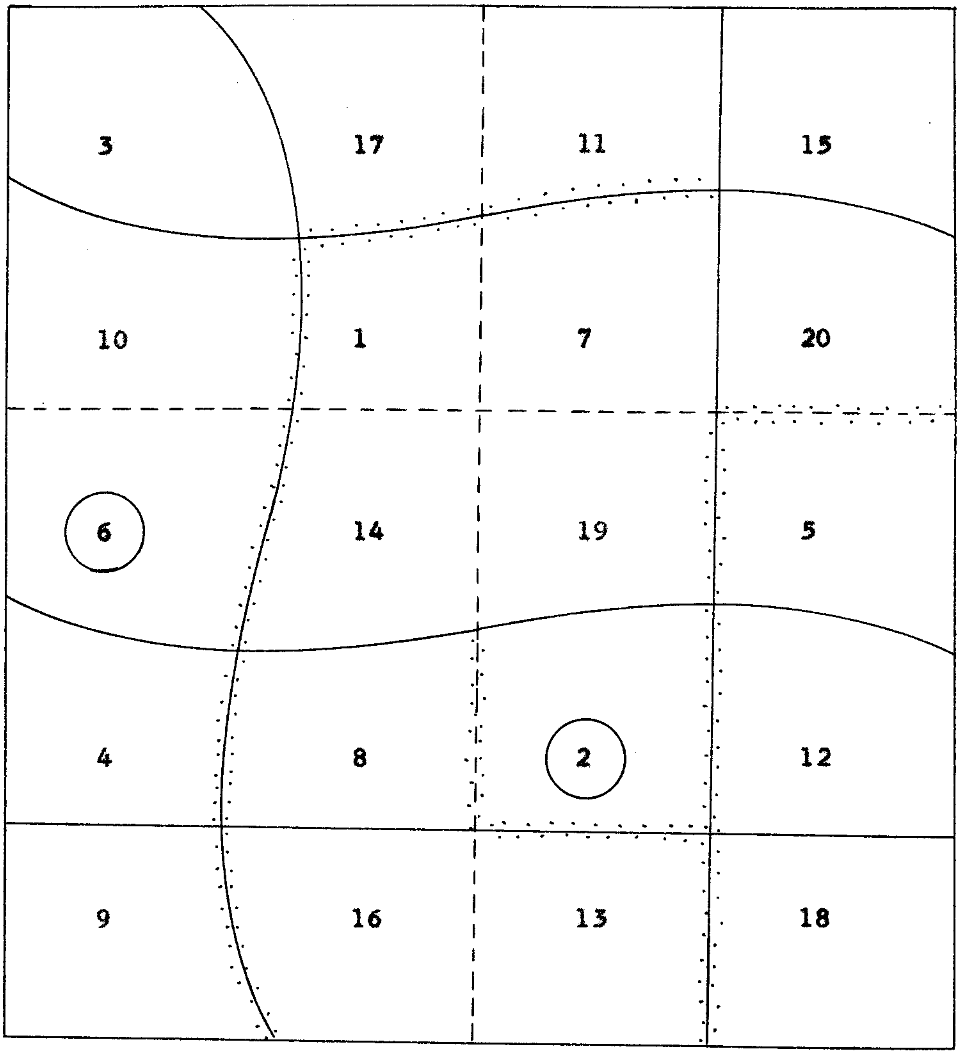
Problem 36C



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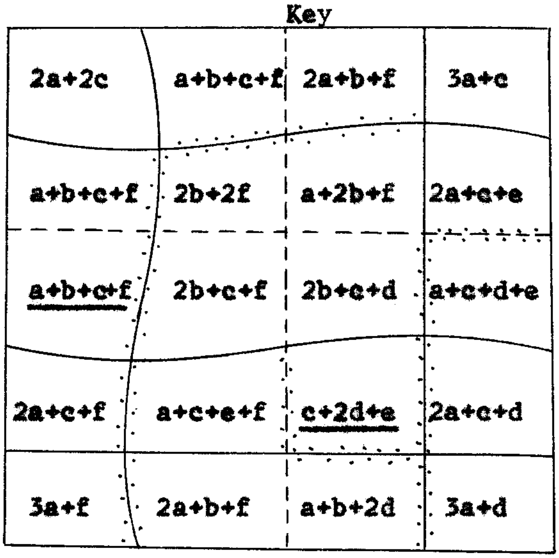

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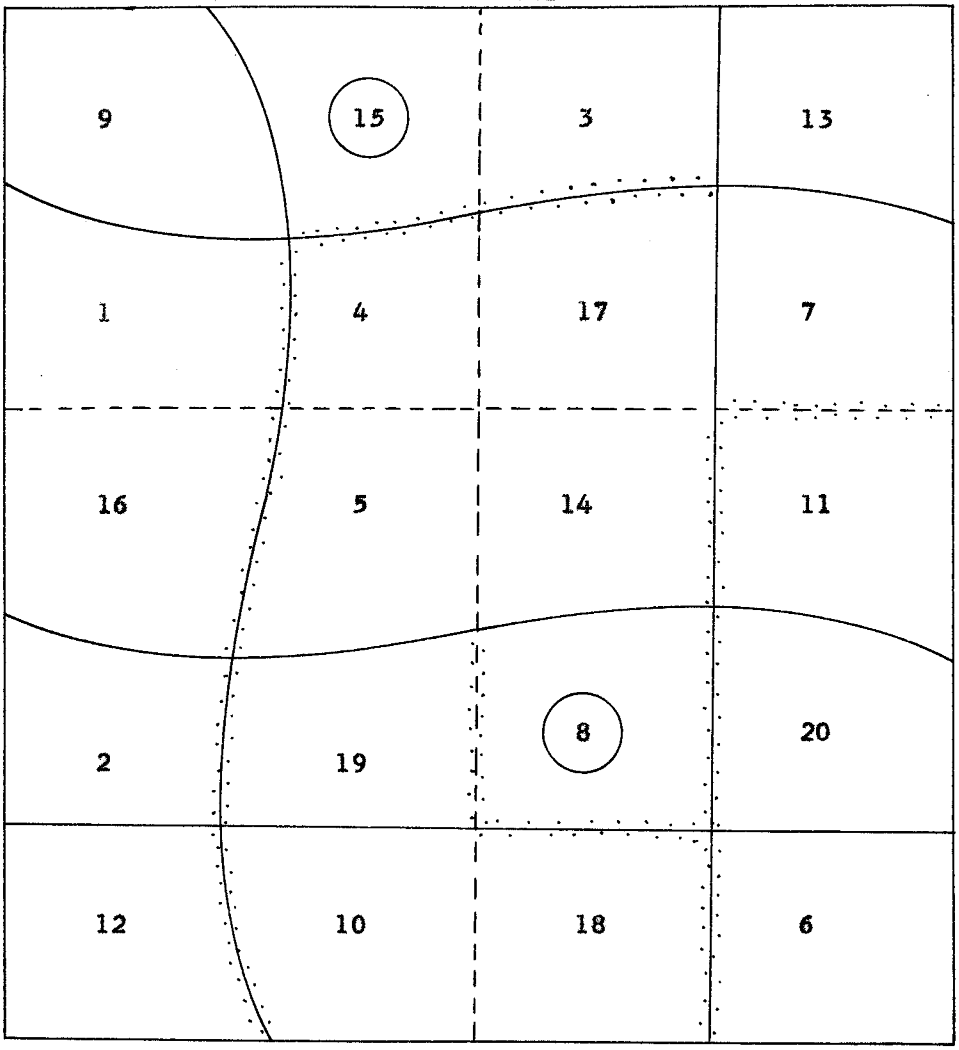
Problem 36D



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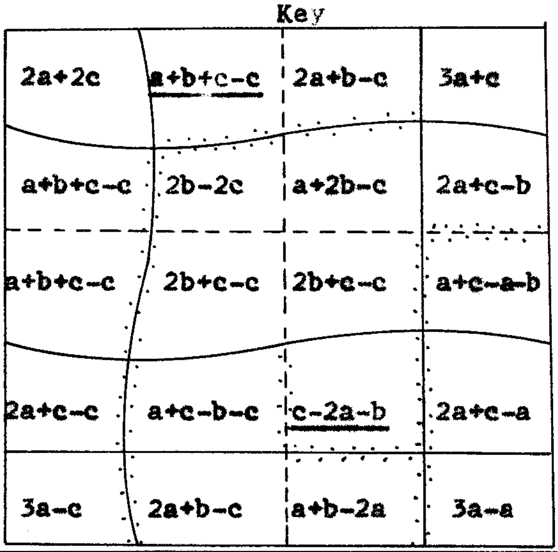

Note: lines or portions with dots along both sides appeared in red in the original.

APPROVAL SHEET

The dissertation submitted by Hermelinda M. Fogliatto has been read and approved by five members of the Department of Psychology.

The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the dissertation is now given final approval with reference to content, form, and mechanical accuracy.

The dissertation is therefore accepted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

October 8, 1963
Date

Signature of Adviser